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ABSTRACT

The goal of the Agam Program is to teach visual literacy to preschoolers. The Agam Project implemented the program in Israel in 1983. This report summarizes the second cycle of research on the program, which was conducted in 1985-87. The Agam Program integrates visual concepts with specific skills and develops specific cognitive processes. The program is for children aged 3-6 years and for various types of preschool classrooms. To evaluate the program, project staff adopted a research design which integrated quantitative and qualitative methodologies. The sample was made up of 25 matched pairs of preschool classes. Children in the Agam Program were better able to identify and apply visual concepts than other preschool children. Effects of the program generalized beyond the program's specific tasks. Children in the program scored higher in fine motor tasks and mathematics readiness. Naturalistic observations provided evidence that children received the Agam Program with enthusiasm. Non-social and non-verbal children were dramatically helped by the program. Recommendations for wider implementation and continued development of the program are offered. An extensive reference list is provided. Appendixes include a description of theories of visual congnition and a collection of program materials. (BC)

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# THE AGAM PROJECT

## CULTIVATING VISUAL COGNITION IN YOUNG CHILDREN

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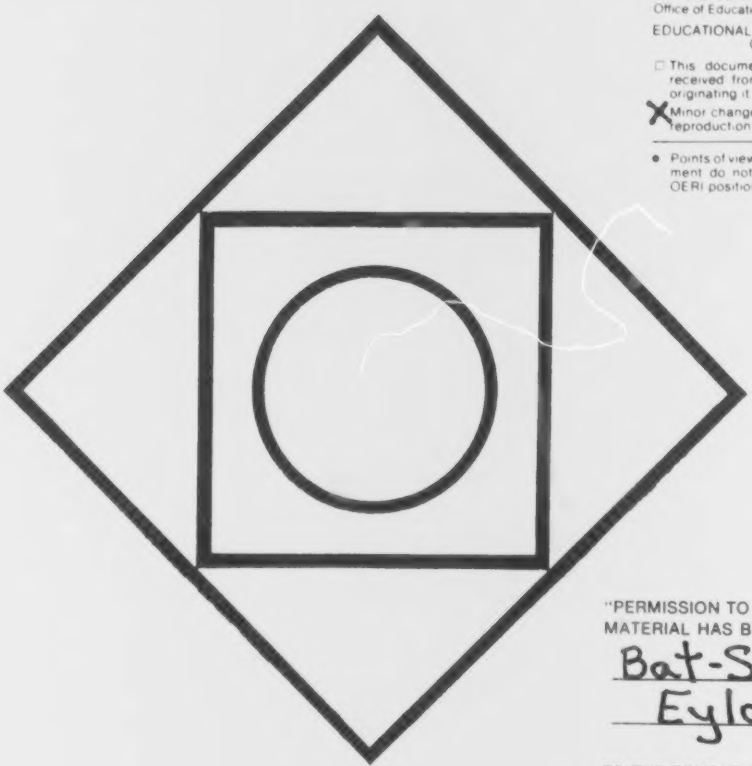

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A RESEARCH AND DEVELOPMENT REPORT
OF THE AGAM PROJECT
December 1990

THE AGAM PROJECT
DEPARTMENT OF SCIENCE TEACHING
THE WEIZMANN INSTITUTE OF SCIENCE – REHOVOT – ISRAEL

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Philosophy is written in this grand book -- I mean the universe -- which stands continually open to our gaze, but it cannot be understood unless one first learns to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles and other geometrical figures, without which it is humanly impossible to understand a single word of it; without these, one is wandering about in a dark labyrinth.

Galileo Galilei
II Saggiatore (1623)

# CULTIVATING VISUAL COGNITION IN YOUNG CHILDREN:
# A RESEARCH AND DEVELOPMENT REPORT OF THE AGAM PROJECT

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December, 1990

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# CULTIVATING VISUAL COGNITION IN YOUNG CHILDREN:

# A RESEARCH AND DEVELOPMENT REPORT OF THE AGAM PROJECT

September 1990

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# ABSTRACT

The Agam Project represents a unique collaboration between a visual artist and a center devoted to scientific research and education. The main purpose of this effort is to help young children develop their visual thinking, as a means to improve their over-all cognitive development.

The vehicle for achieving this goal is through a systematic and innovative curriculum, created by Yaacov Agam, and refined, implemented and evaluated by the staff of the Agam Project in the Department of Science Teaching at the Weizmann Institute of Science.

This progress report presents the second cycle of development and research, which involved 25 pairs of preschool classes. Each experimental class was matched with a comparison class. Ten of the 36 units in the Agam Program were taught to the children in the experimental classes, over a two-year period (1985-7).

Results of the extensive testing demonstrate that children in the experimental classes performed significantly better than children in the comparison classes on tests measuring basic visual concepts and skills. Research also shows that the effects of the Agam Program go beyond the specific tasks presented in the program. For example, the children trained in the Agam Program demonstrated a statistically significant improvement on tests measuring general intelligence and math readiness.

The transfer effects were statistically equivalent for diverse groups of children, i.e. high and low intelligence, priviliged and underpriviliged, boys and girls, verbal and nonverbal.

The program itself was enthusiastically received by the preschool children, as documented in numerous naturalistic observations and by a controlled study using a visual projection test. Also, the program had a dramatic impact on "special children" in terms of their self-image, social adaptation and cognitive development; these children initially intended to be introverted and/or nonverbal.

These results -- and others -- support the conclusion that the Agam Program makes important contributions to children's cognitive development, in a variety of fields. Recommendations for future work include: developing the other units of the Agam Program, establishing a specially-funded implementation center, and conducting more longitudinal research.

# EXECUTIVE SUMMARY

## 1. Overview of the Agam Project

The Agam Project was initiated in 1983 by senior staff of the Department of Science Teaching in the Weizmann Institute of Science. Work focused on the Agam Program, a preschool curriculum designed by Yaacov Agam to teach visual literacy. The work consists of (1) adapting the curriculum to Israeli preschools, (2) implementing the program, (3) evaluating its implementation, (4) conducting relevant educational and cognitive research, and (5) developing possible extensions to the program.

The first cycle of research and development was conducted in 1983-5. This report summarizes the second cycle of research and development, conducted in 1985-7.

## 2. The Significance of Visual Cognition

A review of human intelligence research and educational work shows that visual cognition is an important aspect of human cognition and that it has wide-ranging significance in many fields. Although the training of visual cognition has been traditionally neglected, research indicates that early and systematic training in this area is desirable. Thus, it appears that a significant need exists for (1) the design of an appropriate educational program, to systematically develop visual cognition in young children, as well as (2) evaluation and reseach relating to the implementation of such an educational program.

## 3. Description of the Agam Program

The Agam Program is based upon 36 units each of which deals with a different visual concept. The program integrates each of these concepts with specific skills, i.e., identification, memorization, reproduction and reproduction from memory. Pedagogically, the program stresses an activity-oriented approach, many manipulatives, multiple representations of the same concept, small-group work and minimal verbal intervention by the preschool teacher.

The Agam Program is devised to systematically develop the child's visual language, starting with its basic building blocks and continuing with larger and more meaningful units. Moreover, the program can be described as having goals relating to the development of specific cognitive processes i.e., analysis and synthesis, perceptual flexibility, accuracy of visual encoding and decoding, visual memory, immediate visual perception and creativity.

## 4. Implementation

During the present study (1985-7), 10 out of the 36 units in the Agam Program were taught to the participating preschoolers. A study of this implementation shows that the program is appropriate for children aged 3-6; it is also well-adapted for the typical Israeli preschool. Activities are well-adapted for three different preschool frameworks, i.e., the entire class, small-group work, and individualized work. Evaluation of the teacher-training program shows that it is crucial for the success of the Agam Program.

## 5. Research Methodology

There were several goals of research: to evaluate the program's implementation, to assess the cognitive outcomes of the program, to assess the affective outcomes of the program and to explore other possible contributions of the program beyond its professed aims. To achieve these goals, the staff adopted a research design which integrated quantitative and qualitative methodologies. The sample was 25 matched pairs of preschool classes; each pair included an experimental and a comparison class. This design made it possible to isolate the effects of the Agam Program from other effects, such as the children's intelligence.

## 6. Basic Visual Skills and Concepts

Children in the Agam Program demonstrated a significantly higher ability in their ability to identify visual concepts in complex contexts. They demonstrated a more robust understanding of visual concepts, more sophisticated understanding of these concepts and better application of these concepts in complex visual settings. They also performed better on most visual memory tasks. In some of the test items there was no statistically significant difference between the groups.

## 7. Cognitive Transfer Effects

Effects of the Agam Program generalized beyond the specific tasks presented in the program. Children in the Agam Program demonstrated significantly better transfer skills in the area of observation. They were much better able to reproduce a visual stimulus when it conflicted with their "internal image," scored significantly higher in fine-motor skills and in tasks related to mathematics readiness. There were no significant differences in some transfer tasks involving complex visual processes.

Experimental children demonstrated a statistically significant improvement on intelligence tests (about 6 IQ points) from pre-test to post-test, while the comparison children did not. Analysis of test performance shows that the Agam Program was equally effective with children of diverse backgrounds, without regard to sex, socio-economic level or level of intelligence.

It is difficult to make any statistical conclusions about the effect of the program on creativity, given the difficulty in devising test items to measure creativity. Nonetheless, teacher reports, as well as student performance on several test items, suggest that the program improves children's creativity.

8. Children's Perceptions

Naturalistic observations provided much evidence that the children received the Agam Program with great enthusiasm. A follow-up study using a visual projection test provided two explanations. First, the program's activities were intrisically motivating to the children; the students' response to the activities compared favorably to their response to "control" activities, chosen for their high intrisic interest. Second, the diversity of activity types enahnced student interest; while children's reactions to each activity type varied, each child found certain activity types particularly enjoyable. In general, the most popular activities were tasks which involved physical activity or open-ended creativity.

9. Teachers' Perceptions

Teachers noted that the Agam Program contributed beyond the acquisition of specific concepts and skills. They gave extensive examples of how the program was relevant to new situations, new fields, the development of work skills and habits, as well as the development of school readiness, and creative thinking.

10. Effects on Specific Children

Although the data indicate that the Agam Program helped all the participating children, there appeared to be special children who were dramatically helped by the program. Case histories of such children indicate that they tended to be non-social, introverted, and non-verbal. The Agam Program apparently offered these children a means of succeeding, which was otherwise unavailable to them, resulting in marked improvements in their self-image, social adaptation and cognitive development.

## RECOMMENDATIONS

The central goal of the Agam Project is to foster children's visual cognition. Given what we have learned about the Agam Program and about children's abilities in this area, we make the following recommendations, which relate to (a) the implementation of the program, (b) the continued development of the program, and (c) research directions.

### A. Implementation

Our research firmly demonstrates that the Agam Program makes significant educational contributions to preschool children.

We are convinced that proper preservice and inservice training is an indispensible ingredient of the program's success in the preschools.

Currently, costs for participating preschools are relatively high. Thus, in order to implement the Agam Program in a large number of preschools, special efforts must be taken to prepare the proper organizational and economic foundation.

Recommendations:

1) The Agam Program should be made available for wider implementation in Israeli preschools.

2) An implementation center should be established. This center, which would maintain close links with the Agam Project at the Weizmann Institute, would be responsible for all the details involved in initiating the Agam Program in preschools and continuing with proper inservice training.

3) A special fund is needed for the establishment of this implementation center.

4) A cooperative effort should be made to provide preservice training for Israeli preschool teachers. Specifically, a course for preschool teachers on "The Development of Visual Cognition in Preschool Children" (with implications for the teaching of math, art, science and thinking) should be developed cooperatively by a team from the Agam Project and one or more teacher's colleges.

## B. Continued Development of the Agam Program.

As noted above, the present research was based on only 10 of the 36 units in the program. It may be assumed that a full Agam Program will make even greater contributions to preschool children. In order to assess these contributions, it will be necessary to first complete the Hebrew adaptation of the Agam Program; this work involves refining and pilot-testing about 18 additional units.

Recommendations:

1) All the remaining units of the Agam Program should be adapted and tested in a Hebrew version.

2) An English-language version, based upon the Hebrew version, should also be developed.

3) Computer software should be developed to augment the Agam Program, not to replace it. As a beginning, such software could deal with the memorization aspects of the program (e.g., the flash cards found in each unit).

4) Further development of the Agam Program should be more closely linked with the math curriculum group in the Department of Science Teaching. Such a linkage makes sense due to the close connection between visual cognition and the development of early mathematical concepts, especially in the area of geometry; also, this linkage could help insure a continuation of the Agam Program in the early elementary grades.

## C. Research Directions

The orientation of the Agam Project is to conduct "research in context," i.e., research undertaken in relation to a specific curriculum (the Agam Program), a specific audience (preschool teachers and students) and specific concepts (e.g., concepts presented in the program's units). Up to now, most of this research has concentrated on investigating the program's immediate effect.

Recommendations:

1) More emphasis should now be placed upon longitudinal research, i.e., the investigation of possible program effects in the elementary school grades.

2) More emphasis should now be placed on cognitive research within the framework of the Agam Program, i.e., problem-solving and concept development as they relate to visual cognition.

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## INTRODUCTION:

## THE BACKGROUND AND CONCEPTION OF THE AGAM PROJECT

The work presented in this report is based on an unusual collaboration between a visual artist and an institution devoted to scientific research and education. This collaboration is focused on a program and a project.

### A. THE AGAM PROGRAM

For several decades, according to his own account, Yaacov Agam has been concerned about the lack of visual literacy in the general population (Agam, 1984). As an expression of this concern, and with the assistance of a team of educators and psychologists, Agam created a French-language curriculum to develop visual literacy among preschool students (ages 3 to 6 years old).

There are several assumptions underlying this program. First, there is such a thing as visual language, which is composed of basic elements and their interrelationships. Also, like verbal language, visual language is based on a symbol system and it can be creatively applied to thinking and problem-solving in many areas. For this reason, teaching visual language should be viewed as "a basic" and should commence, within the formal school system, at a young age.

The program itself is systematic, progressing in a logical progression from one concept to the next, while incorporating specific skills with each concept. Pedagogically, the program stresses an activity-oriented approach, with many manipulatives, multiple representations of the same concept, and small-group work.

A small part of the program was implemented for a short time, first in France and and later in Venezuela. Although the program met with the enthusiasm of preschool students and educators, its implementation in these countries was not sustained.

### B. THE AGAM PROJECT

In the Spring of 1983, Mr. Agam visited the Weizmann Institute of Science, an institution devoted to basic research in mathematics and the natural sciences. He presented the program to senior staff in the Institute's Department of Science Teaching, which specializes in the on-going and long-term development, implementation, research and evaluation of science curriculum within the

Israeli school system. The Department concentrates on curriculum research and development in the areas of physics, mathematics, chemistry and geology for junior and senior high school students. The Agam Program deals with different subject matter and younger students. Nonetheless, due to the staff's interest in the program's rationale and structure, the Agam Project was initiated.

The goals of the Agam Project are to (1) adapt the curriculum of the Agam Program to Israeli preschools, (2) implement the program in Israeli preschools, (3) evaluate the program's implementation and (4) conduct relevant educational and cognitive research, and (5) develop possible extensions to the program.

The first cycle of development and research was conducted during 1983-5. This cycle focused on 4 pairs of preschool classes; each experimental preschool class was matched with a similar comparison class. On the basis of very promising results (Eylon et al, 1986), a second cycle of development and research was conducted in 1985-7, this time with 25 pairs of preschool classes. The present report summarizes this second cycle of work.

Since its inception, the goals of the Agam Project have included the development, implementation and evaluation of a specific educational program for preschool children: the Agam Program. At the same time, the staff of the Agam Project has taken a special interest in developing an understanding of "the larger issues." In other words, since the areas of visual cognition and visual training are relatively underdeveloped, an important sub-goal of the Agam Project has been to explore the theoretical and pedagogical underpinnings of these areas.

Thus, the Agam Project can be characterized as an effort to bring together theory, research and practice in the development of visual cognition. Such an interplay between curriculum development and educational research can be characterized as "research in context" (see Eylon and Linn, 1989).

The staff of the Agam Project includes science and mathematics educators, cognitive psychologists and preschool educators, as well as secretarial and technical workers.

## C. OVERVIEW OF REPORT

In the pages that follow, we present our work regarding the development and research cycle of 1985-87.

In Part 1, we start by reviewing the significance of visual cognition, dealing with a brief history of human intelligence research, the nature of visual cognition, and the training of visual cognition. In Chapters 2 and 3, we describe the Agam Program on several different levels and discuss its implementation within Israeli preschools; included here is a treatment of the essential teacher-training program.

In Part 2, we outline our research methodology, which integrates qualitative as well as quantitative work. In chapters V to IX, we present our research findings, in terms of basic visual skills and concepts, cognitive transfer effects, children's perceptions, teacher's perceptions and effects on special children.

In Part 3, we discuss these results within the context of educational research and practice. Based upon these results, we conclude the report with specific recommendations for the future.

# I. THE SIGNIFICANCE OF VISUAL COGNITION

> When I was a kid growing up in Far Rockaway, I had a friend named Bernie Walker. We both had "labs" at home, and we would do various "experiments." One time, we were discussing something -- we must have been eleven or twelve at the time -- and I said, "But thinking is nothing but talking to yourself inside."
>
> "Oh yeah?" Bernie said. "Do you know the crazy shape of the crankshaft in a car?"
>
> "Yeah, what of it?"
>
> "Good. Now, tell me: how did you describe it when you were talking to yourself?"
>
> So I learned from Bernie that thoughts can be visual as well as verbal.
>
> -- Richard P. Feynman (1988)
> Noble Prize-Winning Physicist

Before describing the Agam Program in detail, it would be useful to place this curriculum in perspective by discussing the topic of visual cognition.

This discussion will begin with an account of human intelligence and with the well-documented claim that visual cognition plays an important role in human intelligence. Next, visual cognition will be briefly explored in terms of its two complementary aspects: visual recognition and visual imagery. With this background, it will be possible to explore the significance of visual cognition generally and in specific fields. The discussion closes with a summary of the main points and with two central conclusions.

## A. VISUAL COGNITION AND HUMAN INTELLIGENCE

Through our different senses, we receive different types of information, e.g., verbal, visual, acoustic and kinesthetic. Researchers in the field of human intelligence try to understand the interaction between this information and an individual's mental operations.

One of the first researchers of human intelligence who recognized the importance of spatial intelligence (as well as its non-dependence upon the verbal and logical intelligences) was the pioneering psychometrician L.L. Thurstone. Other researchers, such as Truman Kelley and A. A. H. Koossy, continued in this direction.

Recently, the importance of visual cognition in human intelligence has been highlighted. As Pinker (1984) states:

> "Thus visual cognition, no less than language or logic, may be a talent that is central to our understanding of human intelligence."

Pinker bases this claim on the work of such researchers as Shepard and Cooper (1982), Jackendoff (1983), and Johnson-Laird (1983).

In order to appreciate the relationship between visual cognition and human intelligence, an obvious first step is to ask: what constitutes human intelligence? Various researchers have attempted to answer this question and have arrived at different conclusions.

## 1. A Brief History of Intelligence Research

There is a spectrum of different approaches to the study of human intelligence. At the extremes are two ideas: (1) intelligence is a unitary concept, and (2) intelligences are multiple.

In the early 1900's, the tests of Alfred Binet (Binet, 1911) were designed as empirical devices for identifying mildly-retarded and learning-disabled children who needed special help. Only later did the American theoreticians of human intelligence -- such as H.H. Goddard, L.M. Terman, E.L. Thorndike and R.M. Yerkes -- promote the view that I.Q. scores measure a unitary and innate entity (Gould, 1981). This became the basis of the "psychometric" approach.

Shortly afterwards, a biologist, Jean Piaget, analyzed children's answers to these tests and noticed that there was a correlation between the children's age and their characteristic errors. This discovery motivated Piaget to develop a unique and powerful theory about human cognition.

Piaget's theory is based upon the notion that individuals develop their mental powers in stages; these stages depend upon the individual's age and upon the development of specific logical-mathematical operations. Piaget created a model of human intelligence which relates to the basic categories of time, space and causality. The philosophical foundation of this approach is based upon Kant, who argued that rational thought relies upon logical operations.

Another approach to the study of human intelligence is the psychology of information processing. Adherents to this approach focus on how people solve specific problems, in terms of information input, processing and output. In other words, they try to analyze and understand each of the various steps undertaken by a problem-solver, from the time the background information is received until the time a solution is achieved.

According to Gardner (1983), these three approaches -- the psychometric testing of I.Q., Piaget's theory of cognitive development and the psychology of information processing -- focus only on particular aspects of human intelligence while ignoring others. Gardner proposes that there are many different types of intelligence, each based upon a unique "symbol system" and each distinct from the rest.

According to this view, the other theories are not sensitive enough to account for the wide variety and variability of intelligence within human cultures. These theories do not relate to the biology of the brain nor do they explain the phenomenon of human creativity. Gardner argues that the ability to use different symbol systems as tools for expression and communication is uniquely human and not shared by the rest of the animal kingdom. On this basis, Gardner proposes a theory of multiple intelligences, each of which is based upon a different symbol system.

Gardner proposes seven different types of human intelligences: verbal, logical-mathematical, visual-spatial, musical, kinesthetic, interpersonal and intrapersonal. Each corresponding symbol system serves as a distinct "language" for the corresponding type of intelligence. Moreover, the development of a particular intelligence depends upon the development of the corresponding symbol system.

It is useful to bear in mind several observations, in connection to this theory of multiple intelligences. First, each type of intelligence contains a variety of different aspects. For example, regarding verbal intelligence, a person may excel in the writing of prose but not in oral expression. Second, the different intelligences are distinct and not dependent upon each other. This claim is supported by a common observation: it is usally easy for a person to draw while listening to music (i.e., utilizing two different types of intelligence), but nearly impossible for a person to simultaneously listen to one kind of music while playing another. Third, it is important to recognize that each individual has a unique "profile" of intelligences, with some people excelling in more than one type of intelligence.

This brief discussion of human intelligence research would be incomplete without mentioning the essential role of environmental stimulation. Research clearly indicates that without adequate stimulation, i.e., the vital interplay between the organism and the environment, the development of intelligence will be thwarted. It is especially important that such environmental stimulation takes place in the early years.

## 2. Visual Cognition: What Is It?

As mentioned above, some of the early researchers in the study of human intelligence identified spatial ability as distinct from verbal and logical abilities. Many psychometricians, using statistical tools based upon factor analysis, tried to "tease out" the components of spatial ability found in intelligence tests. Their numerous efforts -- spanning over 50 years -- produced a variety of competing terms and concepts (Guttman et al., 1990).

According to Gardner (1982), spatial intelligence includes the following capacities:

(1) to perceive and recognize instances of the same element,

(2) to transform and manipulate these perceptions,

(3) to make mental images and to transform them, and

(4) to produce a graphic likeness of spatial information.

Although these capacities may be independent of each other, Gardner suggests that "they operate as a family, and use of each operation may well reinforce use of the others." It is interesting to note that the abilities to create and to transform mental images are not dependent upon physical visual stimuli; individuals blind from birth also possess these abilities (For this reason, Gardner speaks of "spatial intelligence" instead of "visual intelligence," although the term used in the present discussion is "visual cognition").

Pinker's definition of visual cognition, which includes Gardner's conception of spatial intelligence, is that it consists of two complementary components:

(1) Visual recognition, which focuses upon the representation of visual information by the individual, and

(2) Visual imagery, which focuses upon how the processes of memory and reasoning act on visual objects and visual representations to produce mental images.

There are a variety of theories which attempt to explain how people process visual information, both in terms of visual recognition and visual imagery. A summary of these theories is presented below (for a more detailed treatment, see Appendix 1).

2.1 Visual recognition. How does an individual absorb visual information? Embedded in this question is an unsolved riddle: what is the difference, if any, between visual perception and visual cognition?

According to one school of thought, perception precedes and does not include cognition. For example, in the theory of Marr and Nishahara (1978, 1982) there are primary visual processes which set the basis for visual recognition and visual imagery.

On the other hand, a contrary view is presented by Arnheim (1969), who claims that visual perception is characterized by important cognitive processes. While Arnheim's position reflects a more global philosophical approach, the cognitive research of Uttal (1983) is similar in orientation. In his investigations of "form detection," Uttal defines the "stages of perception" as "detection, discrimination, recognition and perception." Like Arnheim, Uttal identifies visual perception as including visual cognition.

2.2 Visual imagery. How does an individual represent and manipulate mental images? Again, the different theories which address this question represent two different schools of thought: propositional and imagist.

The propositional approach argues that mental images are represented by logical propositions and that one's experience of "seeing" detailed mental images is secondary, i.e. an "epiphenomenon." For example, Olson and Bialystock (1983) summarize their research with the claim that non-imagist and logical "spatial structures" are "... the furniture of the mind; the rules and representations used in perceiving and thinking about space. They are the structures of inner space." These propositions are basic to both verbal and spatial thinking.

The opposite approach is taken by the imagist school of thought, which claims that mental images are internalized visual images. For example, Kosslyn (1980, 1981, 1984, 1988) developed and tested a theory of mental imagery which is based upon specific visual operations.

It is interesting to note that each of these apparently contrary positions is supported by empirical experimental work. Perhaps these approaches are not mutually exclusive. At any rate, the current trend in the field of visual cognition, as a whole, is two-fold: (1) to identify basic visual cognition processes which can be represented and simulated by the computer, and (2) to find the connection between these same visual cognition processes and specific neurological processes in the brain.

## B. SIGNIFICANCE IN VARIOUS FIELDS

Not only is visual cognition an important aspect of human intelligence, as described above, but it also plays a significant role in many fields of human endeavor.

Generally speaking, as Pinker (1984) was quoted above, visual cognition is at least as important in the understanding of human intelligence as are the areas of language or logic. Gardner (1982) proposes several general uses of this type of intelligence: orienting oneself in various locales, recognizing objects and scenes, working with graphic depictions of reality (e.g., maps, diagrams, 2-D or 3-D representations), being sensitive to artistic dimensions (e.g., the tension, balance and composition of a painting), being sensitive to similarities across diverse domains (i.e., possessing a metaphoric ability) and using mental models or images in various types of problem-solving.

More specifically, some research has attempted to link proficiency in visual cognition with success in specific subject-matter domains. One of the first research projects of this kind was conducted by Smith (1964), who tested the spatial skills of a large number of British elementary school children. Based upon his findings, Smith reached the following conclusions:

* Schools place primary emphasis upon the development of verbal skills and neglect the development of spatial skills. As a result, schools produce more students with high verbal skills than students with high spatial skills.

* Longitudinal research shows that success on tests

measuring spatial ability are excellent predictors of future success in mathematics, among both boys and girls.

* These spatial ability tests are able to measure such skills as: the ability to think abstractly and analytically, the ability to see spatial relationships between two and three dimensions, the ability to manually manipulate objects, as well as other skills.

* Such above-mentioned skills are required for success in such areas as higher mathematics, engineering, various fields of science and the technical professions.

* Verbal tests do not test for the appropriate skills in these areas, a fact which is often ignored in schools.

These empirically-based conclusions resonate with the more intuitive feelings of many designers and engineers. For example, in his book *Invention and Evolution: Design in Nature and Engineering*, French (1989) contrasts verbal with visual thinking and concludes that one can't design with words alone:

> "*Homo jabber* he is no end of a fellow, and looks down on humble *Homo faber*, the engineer and the designer."

Shepard (1978) explains the importance of visual imagery in problem-solving, in the sciences and the arts, by presenting a variety of real-life examples. According to these examples, a number of outstanding scientists built their theories on the basis of specific mental images (e.g., Einstein, Watson and Crick). The advantage of thinking with mental images, according to Shepard, is that one can simultaneously see different connections and relationships in a dynamic way. Shepard and Cooper (1982) point out that the use of visual analogies, based on concrete mental images, is effective in the explanation and understanding of abstract concepts in science and mathematics (e.g., electromagnetic fields).

According to a wide variety of educational research, there seems to be no doubt that spatial ability is highly correlated and/or directly related to success in mathematics, engineering and the sciences (Battista et al., 1982; Bishop, 1978, 1980; Clements, 1983; Linn and Petersen, 1986; Salomon, 1974; Stuart and Plunket, 1979). However, many controversies and open questions remain regarding the nature of spatial ability, its development, its sub-components and their relationships to success in specific tasks (Eisenberg and Dreyfus, 1989; Mitchelmore, 1980).

## C. THE TRAINING OF VISUAL COGNITION

Given the educational importance of visual cognition, an obvious question remains: Is it trainable?

According to research, the answer is affirmative. It is worthy of note, however, that the overwhelming majority of these studies relate to schoolchildren from grades 4-12 (see review in Ben-Chaim et al., 1985). In one of the few studies undertaken with preschool children, Cox (1978) demonstrated that 5-year-old children could be trained in perspective-taking skills; moreover, these children demonstrated the ability to transfer this ability to new but related problems.

Several reviews which evaluate early childhood programs conclude that normal preschool children can be trained in visual skills (Grossman, 1970; Fowler, 1983, pp. 235-242). However, these programs were conductad mainly within the framework of art education. Other programs which develop visual skills can be found in the field of special education, e.g., the Frostig-Horne visual perception program (Weiderholt & Hammill, 1971), and others (Kephart, 1971; (Getman, Kane, Halgren, & McKee, 1968). Common practice thus limits visual thinking instruction in preschools to art or to special education.

This neglect of programs to develop visual cognition in preschool children is rather surprising, in light of (1) the importance of visual cognition to intelligence, as discussed in the beginning of this chapter, (2) the fact that visual imagery plays a significant role in the thinking of young children (Kosslyn, 1980), and (3) the current interest to develop thinking skills.

The teaching of thinking skills is recognized as a high priority in education (Glaser, 1984, 1985) and a variety of educational programs for elementary school children have been designed to teach various cognitive skills (Chance, 1986; Costa, 1985; Nickerson, Perkins, & Smith, 1985; Segal, Chipman, & Glaser, 1985). Such programs include the Instrumental Enrichment Program (Feuerstein, Jensen, Hoffman, & Rand, 1985) Philosophy for Children (Lipman, 1985), the Problem Solving and Comprehension Program (Whimbey & Lochhead, 1980), the CoRT Thinking Program (de Bono, 1976), and the Productive Thinking Program (Covington, 1985). These and other programs cover various important aspects of thinking. However, the emphasis is mostly on verbal, conceptual, and logical thinking. The Instrumental Enrichment Program is an exception in that it includes the systematic improvement of visual thinking skills as part of a wider program which includes also logical and verbal skills; however, this program is geared for disadvantaged youth, not the normal child.

In short, evidence is strong that visual skills can and should be taught, even in preschools, but educational practice falls far short of this mandate.

## D. CONCLUSIONS

The following points should be clear from the above discussion:

(1) *Visual cognition is an important aspect of human thinking and human intelligence*. If one accepts human intelligence as a unitary concept, visual cognition is an essential aspect of this intelligence. Alternatively, if one accepts the theory of multiple intelligences (Gardner, 1982), visual cognition is a specific human intelligence in its own right.

(2) *Research clearly indicates that visual cognition has wide-ranging significance*. This significance has been documented, both generally as well as in specific domains, such as mathematics, science, engineering, architecture and art.

(3) *The training of visual cognition has been traditionally neglected, limited to the fields of art education and special education*. Schools stress the training of verbal cognition, which is based on a verbal symbol system, even though verbal language develops "naturally." Environmental stimulation of this natural process can be quite beneficial. Likewise, schools should also train visual cognition, which is based upon a visual symbol system, and which also develops "naturally." This latter training should be geared to all children; it would not duplicate or replace efforts in art education or special education.

(4) *Early and systematic training in visual cognition would provide a special advantage*. Support for this hypothesis comes from educational research, although more studies are needed.

It is important to note that the cognitive sciences now provide researchers with the orientation and tools with which to evaluate and study visual cognition. As a result, both basic and applied research in this field is growing.

Two conclusions are unavoidable:

(1) A significant need exists for an appropriate

educational program, designed to systematically develop visual cognition in young children.

(2) Evaluation and research relating to such an educational program should be conducted, in accordance with current advances in the cognitive sciences.

# II. DESCRIPTION OF THE AGAM PROGRAM

> "My method of visual language ... (has) the aim of introducing into the school system a visual education, parallel to, and integrated with, verbal education. In such a way, we would be able to balance and develop both our verbal and our visual capabilities."
>
> -- Yaacov Agam (1981)

The Agam Program may be described on several different levels. Due to the unusual and innovative nature of this program, in this chapter we present these levels in a "bottom-up" sequence, i.e., first presenting an action-oriented description of the program, followed by a description of its organization, and then presenting a description of the program's rational and goals, its didactic approach and comparison with related programs. Thus, each successive level of description may be represented by a different question:

A) How does the program work "in action"?

B) How are the learning units organized?

C) What are the program's rationale and goals?

D) What is the program's didactic approach?

E) How does the program differ from related programs?

These questions are discussed in the following sections.

## A. THE PROGRAM IN ACTION

It's a sunny day. The 3- and 4-year old children are digging tunnels, catching insects, playing on the swings, and pretending they are the heroes from their favorite television shows.

"It's time for the Agam Program!" announces Rachel, the preschool teacher.

The children drop their shovels and buckets, climb off the play equipment, remove their costumes and run inside, bushing the dirt off their hands, and sit in their chairs. The noise dies down.

"I want to show you something." Rachel is about to introduce a new unit. She holds up a flat plastic form with one hand, facing the children. She places the index finger of her other hand on the form, at one corner at the bottom. Rachel vertically traces one side of the plastic form with her finger, making a buzzing sound. "Boom!" she suddenly exclaims, as her finger reaches the first corner.

Then, she continues and horizontally traces the second side. "Buzzzz....Boom!" she says again, as her finger reaches the second corner. The children are still quiet and attentive. Rachel continues tracing, this time down the third edge, in the direction to the floor, and then back to the first corner. "Buzzz....Boom! .........Buzzz....Boom!"

She looks up at the children and explains: "This is a shape. This is a square."

Now the preschool teacher holds up a plastic rod, identical in length with the square's side. She places it against one side's edge, then against each of the other three sides. Four equal sides. She invites each student to do the same activity, this time with plastic squares of different colors and sizes. Through their own actions, the children discover that each square has its matching length, and that "squareness" is a property that goes beyond color and size.

Roni, a 3-year-old, measures his square with a rod. So does his classmate, Sarah. Later, together they will be given a more complicated task: to make a larger plastic square made up of smaller ones. Again, they must check to see that all four sides are equal in length.

In the coming days and weeks, the children in Rachel's preschool will identify squares in their environment; they will play memory games based on cards with combinations of squares with different sizes and in different orientations; they will reproduce combinations of squares with plastic transparencies, create squares with their bodies and with various materials. Then, they will draw squares, first using dotted papers as guides and then, on blank pieces of paper. They will reproduce squares from memory -- using transparencies and using pencils -- after seeing flash-cards for 1-2 seconds. And they will engage in open-ended activities which allow them to creatively apply the concept.

Before learning about the square, the children engaged in about 40 activites relating to the circle. After completing these first two units in the Agam Program, the children are ready to learn about a new concept in Unit 3: Patterns. The preschool teachers learn that in the Agam Program a "pattern" is formally defined as "a periodic sequence of elements which occurs in space and/or time." The children never receive such a formal explanation. Instead, they explore this concept intuitively, through another 30-40 activities which integrate the new concept of "pattern" with the same skills developed in each of the units: identification, memorization, reproduction, reproduction from memory and creative production.

## B. ORGANIZATION OF THE LEARNING UNITS

The Agam Program includes 36 units. These units progressively and logically integrate specific concepts with specific skills. Thus, logical relationships exist between the concepts covered by each of these units. At the same time, there is a progressive and consistent structure of the skills which are developed in each of these units.

### 1. The Logical Relationships Between the Concepts

The concepts presented in the units can be viewed as elements in a "visual alphabet" or as concepts which can be used to produce higher-order units, such as "words," "sentences" or "stories." Table 2.1 lists the units in the Agam Program.

The basic elements of the "visual alphabet" deal with basic shapes (e.g., circle, square, triangle, etc.), orientations (e.g., horizontal, vertical, oblique) colors (e.g., red, yellow, blue, white and black); dimensions (e.g., length, width, height and time) and other visual elements (e.g., point, curved line). It is important to note that each visual element is first introduced in its isolated form. Subsequently, the same element is shown in combination with other visual elements. For example, the unit on Circle is taught independently, as is the unit on Square. Subsequently, the relations between these two concepts are taught in the unit, Circle and Square. Likewise, the units dealing with horizontal and with vertical lines are each presented before they are combined in the unit on Horizontal & Vertical. This progressive logic repeats itself throughout the program.

In addition to the above-mentioned "visual elements," the program includes concepts relating to "combination rules" and "visual grammar." These concepts are useful in generating additional visual combinations. Such units include Large, Medium & Small, which focuses on the size relationship in combinations, such as a big and small triangle, Angles and Proportions. Likewise, the unit on Patterns, focuses on the concept of a periodic series of shapes, and the unit on Symmetry, teaches how, for example, to turn a right-angled triangle into an isosceles triangle

Table 2.1

**The Units in the Agam Program**

1. Circle
2. Square
3. Patterns
4. Circle & Square
5. Flash Identification
6. Horizontal
7. Vertical
8. Horizontal & Vertical
9. Oblique
10. Horizontal, Vertical & Oblique
11. Triangle
12. Circle, Square & Triangle
13. Variations of Forms
14. Symmetry
15. Curved Line
16. Large, Medium & Small
17. Angles
18. Point
19. Typical Forms
20. Proportions
21. Red
22. Yellow
23. Blue
24. Secondary Colors
25. White, Black & Gray
26. Trajectory
27. From Eye to Hand
28. Numerical Intuition
29. Composition
30. First Dimension
31. Second Dimension
32. Third Dimension
33. Fourth Dimension
34. Letters
35. Visual Grammar
36. Creativity

(by multiplying the right-angled triangle symmetrically), or how to turn a circle into two symmetrical "eyes". Finally, the visual "sentences" turn into "stories" in such units as Flash Identification, which trains the child with pictures, such as, a hammer driving a nail into a plank.

## 2. The Structure Within Each Unit

Each booklet's activities are organized into a standard sequence of five categories: identification, memory, reproduction, reproduction from memory and creative production.

Thus, instruction starts with passive identification of the unit's concept and continues with its active discovery, first in its simple form (e.g., looking for plastic circles hidden by the teacher in the classroom), and then, in tasks that require visual analysis with concrete objects (e.g., finding squares in picture books). These are the "identification" activities.

Once children can identify the concept, "memory" activities are presented. Most of these activities use about 30 different flash cards, each containing a visual variation of the unit's concept. Typically, from 9-12 exemplars are placed before the children who are then quickly shown one, which they must identify by pointing to the correct exemplar. Afterwards, students may be shown from two to four stimulus cards in a row.

Regarding these memory cards, it is interesting to note that in the Agam Program, two concentric circles and two intersecting circles are two different "visual words" with two different visual appearances, each of which deserves to be learned. While it is impossible to teach all possible "words", or visual combinations of the elements taught, an effort is made to give many examples of the combinatorical nature of each concept, via the different memory cards.

Next, in each unit, activities of "reproduction" and "reproduction from memory" are presented. In the first group of these activities, the child is presented with examples of the concept and is asked to reproduce them via various means, e.g. the body, transparancies, plastic forms, found objects and -- at the end -- graphically, with pencil and paper. In the latter group of these activities, the child is shown examples of the concept for a brief time, and is asked to reproduce them from memory.

Finally, in each unit, open-ended activities allow children to creatively apply the given concept.

## C. RATIONALE AND GOALS

The rationale of the Agam Program is based upon the significance of visual cognition (see Chapter I). Thus, this curriculum is devised to systematically develop the child's visual language, starting with the basic building blocks and continuing with larger and more meaningful units. The assumption is that developing the individual's visual language will substantially improve his or her visual cognition, which may be used in a wide variety of domains. In this sense, the program's content is viewed as one of "the basics." Moreover, the assumption is that students will be able to use the visual language creatively, generating new combinations of elements and meaningings, much as one might do with the verbal language.

Given this rationale, the program can be described as having goals relating to the development of specific skills or processes such as (1) analysis and synthesis, (2) perceptual flexibility, (3) accuracy of visual encoding and decoding, (4) visual memory, (5) immediate and direct visual perception and (6) creativity. These goals are discussed below:

### 1. Analysis and Synthesis

According to Yaacov Agam, a primary objective of his method is "to educate the eye", namely, to allow children to comprehend the universe of forms which surrounds them, to decipher in it the basic elements and to be able to synthesize complex visual forms from simple basic elements. The Agam Program teaches the child to analyze his environment into simpler elements (e.g., finding examples of a visual element, such as a circle) in one's environment. The program also teaches children to synthesize new shapes (e.g., creating new shapes from transparencies with different shapes)

### 2. Perceptual Flexibility

The ability to move between an analytic and a synthetic mode of perception can be considered as one kind of perceptual flexibility that the program attempts to promote. Flexibility of perception is expressed also in the ability to perceive correctly perceptual changes in shapes, e.g., recognizing the square as such even when it is turned around to stand on its corner, or to identify a shape when it appears in combination with other shapes.

Flexibility of perception is also expressed in the ability to choose the right level of detail in visual perception. Thus, the program teaches the children both to perceive horizontal and vertical lines in a square window, and sensitizes them to the fact that a window may be a component of a repetitive series in the front of a building.

### 3. Accuracy of Visual Encoding and Decoding

An important component of this skill is the ability to see what things really look like rather than to depend on one's predetermined verbal conceptions. This ability is trained by tasks which require precision in visual perception and reproduction.

### 4. Visual Memory

The goal of developing visual memory occupies a central place in the program. Within each unit, children work with "flash cards" to develop their memory of the relevant elements. Between the units, the program contains a systematic increase in complexity of the images that a child learns to manipulate mentally (e.g., visual elements to stylized pictures of everyday objects to mental images of actual objects).

### 5. Immediate and Direct Visual Perception

Another goal of the program is to train children to develop a reflexive mode of visual perception, i.e., perception that does not depend upon translation to a verbal mode but is both immediate and direct. This goal is achieved through minimal use of verbal instruction and through the memory exercises, in which a visual stimulus is presented for a very short time.

### 6. Creativity

A final goal is the development of creativity in the visual domain and in all other fields of human endeavor as well. The means for achieving this goal are several. First, toward the end of each unit, open-ended activities invite the child to make creations using the visual concepts learned. These activities employ a variety of materials, such as plastic forms, transparencies, clay, paper cut-outs, etc. Second, the child is invited to freely create in the "Agam Corner," throughout the day. Finally, the program as a whole is aimed at developing the visual language skills of the individual, thus providing the child with a powerful vehicle for engaging in the creative process.

## D. DIDACTIC APPROACH

In achieving its goals of teaching a visual language and educating the eye, the Agam Program uses several distinguishing didactic means which include (1) a structured approach, (2) multiple modes of representation, (3) a cumulative presentation strategy and (4) minimal use of verbal instruction.

### 1. A Structured Approach

As mentioned above, there is a structured and logically-organized progression between the learning units as well as within each unit (i.e., each unit is organized sequentially into four activity categories: identification, memory, reproduction and reproduction from memory).

This progression carries with it several didactic means. Thus, in the identification activities, the "abstract" concept is presented first; only afterwards does the child search for "concrete" examples of these concepts in the environment. Also, in the reproduction activities, emphasis is placed on reproduction with non-graphic means (reproduction via pencil and paper comes at the very end of these activities). Finally, the Agam Program stresses accuracy of perception and reproduction in its various activities.

### 2. Multiple Modes of Representation

An important feature of the Agam Program is the repeated presentation of the same concept in a large number of activities. Within each unit, a particular concept is taught in over 30 different activities. Multiple modes of representation -- such as those that involve bodily activity, group activity, auditory perception, visual perception, tactile perception , and representation with different types of materials -- are employed to enhance the mastery of each concept. For example, in the unit on Patterns, children are given different auditory codes for circle and square; they are then asked to create a visual pattern by following an auditory dictation of these codes. In other activities, within the same unit, children represent the concept with different materials, e.g. transparencies, plastic forms, construction paper, found objects, etc. This emphasis on multiple representations is intended to help the child flexibility and depth in mastering the given concept.

### 3. Cumulative Presentation Strategy

Another didactic element in the Agam Program is the use of a strict cumulative presentation strategy: Combinations of concepts are taught only after the individual concepts have been mastered. For example, the combination of horizontal and vertical is taught in Unit 8 after both horizontal and vertical are taught separately in Units 6 and 7 respectively; the combination of horizontal, vertical and oblique is contained in unit 10 following the teaching of the concept oblique in Unit 9.

### 4. Minimal Use of Verbal Instruction

Attention is given to the "intuitive" presentation of visual concepts. For example, the square is not introduced as "a rectangle with all sides equal"; rather, students engage in an activities in which they develop an understanding of the concept "square." Rather than supplying verbal definitions, the children are allowed to experience the learned concepts in a direct visual manner. Throughout the program, minimal use is made of verbal instruction. It is assumed that when a visual stimulus is accompanied by a torrent of words, the visual experience may not be well attended to by the child. Generally, verbal labels are supplied only after the concepts have been introduced visually.

Consistent with this same line of thinking, the preschool teachers are encouraged to give non-verbal feedback to children, during the presentation of the various activities. Thus, instead of relying upon the teacher's usual verbal feedback ("Good," "try again," etc.), the children are encouraged to check their own work visually and are given other signals (e.g., a smile, a nod of the head, etc.).

Practicing what it preaches, the teacher-guides of the Agam Program are written in a pictorial language besides the customary verbal description. The verbal text describes each activity, its objectives and the materials it requires. But each activity is depicted also in a series of four pictures (see Fig. 1). These pictures allow, on the one hand, for a quick perception of the activity by the teacher. On the other hand, they raise the teacher's sensitivity to the visual language, and demonstrate concretely that it is this language that the program is intended to strengthen. We may note the resemblance between this feature of the Agam Program and the common method of teaching a second language using the second language rather than the child's mother tongue.

## E. DISTINGUISHING FEATURES OF THE AGAM PROGRAM

Another way to describe the Agam Program is to focus on its main distinguishing features, relative to other curricula for developing visual thinking skills.

First, the approach of many programs is corrective, attempting to correct deficient cognitive functions of the slow learner. The Agam Program, on the other hand, is "preventative" in that it tries to prevent a potential modality of human thinking from not developing.

Second, though many programs are systematic in their didactic approach, the Agam Program's presentation of modular visual concepts that are combined with each other cumulatively according to "grammar"-like rules, is assumed to imitate the learning of a language and make the learning process "generative" in the Chomskian sense (Chomsky, 1957). Because of this quality of the program, it is assumed that the child can learn to generate creatively his own visual language and develop his visual thinking to suit his own specific problem solving needs in the particular domain that interests him.

Third, in terms of the target population, while many programs are designed for relatively well defined groups, such as special education children (e.g., the Frostig-Horne Method), or disadvantaged youth (Instrumental Enrichment), the Agam Program aims at the general population and the normal child.

Fourth, the Agam Program is designed for younger ages than many other programs. For example, while Instrumental Enrichment aims at the adolescent student, the Agam Program is designed for the very young and has been implemented successfully with 4-, 5-, 6-, and 7-year-olds (Eylon, Ben-Dov, Ben-Zvi, Golan, Hershkowitz, Razel, & Rosenfeld, 1988; Eylon & Razel, 1986; Razel & Eylon, 1986). Preliminary results indicate the feasibility of using the program successfully with 3-year-olds. These results will be reported separately.

Finally, the Agam Program addresses a much wider range of visual concepts than do virtually all other programs.

## F. THE AGAM PROGRAM IN ACTION

The following photographs demonstrate how the Agam Program integrates the learning of concepts and skills.

Each of the 36 units, which make up the Agam Program, have the same 5 activity categories: Identification, Memory, Reproduction, Reproduction from Memory and Creative Production.

A

The photographs are organized in the following order:

I. IDENTIFICATION ACTIVITIES

- * Passive Representation of Visual Concepts
- * Active Internalization of Concepts Through Play

II. MEMORY ACTIVITIES

- * Using flashcards to develop visual memory

III. REPRODUCTION

- * Increasing Order of Abstraction
- * Transparancies: Visual Analysis and Synthesis
- * Creative Production

IV. REPRODUCTION FROM MEMORY

V. CREATIVE PRODUCION

OTHER ACTIVITIES

- * Developing Visual Precision
- * Problem Solving

## I. IDENTIFICATION ACTIVITIES

* Passive Presentation of Visual Concepts

A series of circles, decreasing in size
(Unit 1: Circle)

Tracing the edges of a square (Unit 2: Square)

C

* Active Internalization of Concepts Through Play

A discrimination game: jumping on circles (Unit 1)

Playing with circles (Unit 1)

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## II. VISUAL MEMORY ACTIVITIES

Using flashcards to develop visual memory

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E

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## III. REPRODUCTION

* Increasing Order of Abstraction

Using the body to represent circles of different sizes (Unit 1)

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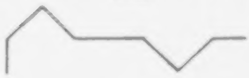
G

Using the body to represent vertical and horizontal lines (Unit 8)

Body representation of a graphic display, i.e.,  (Unit 10)

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Reproduction of a visual model with the use of plastic rods (Unit 10: Horizontal, Vertical and Oblique)

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Graphic representation of the same model, soon after building the plastic model (Unit 10)

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* Use of Transparancies: Visual Analysis and Synthesis

Breaking down the graphic model into its basic parts (analysis) and reproducing it correctly by putting these parts together (synthesis)

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IV. REPRODUCTION FROM MEMORY

The teacher quickly presents flashcards and the children reproduce them from memory, either graphically or with transparancies.

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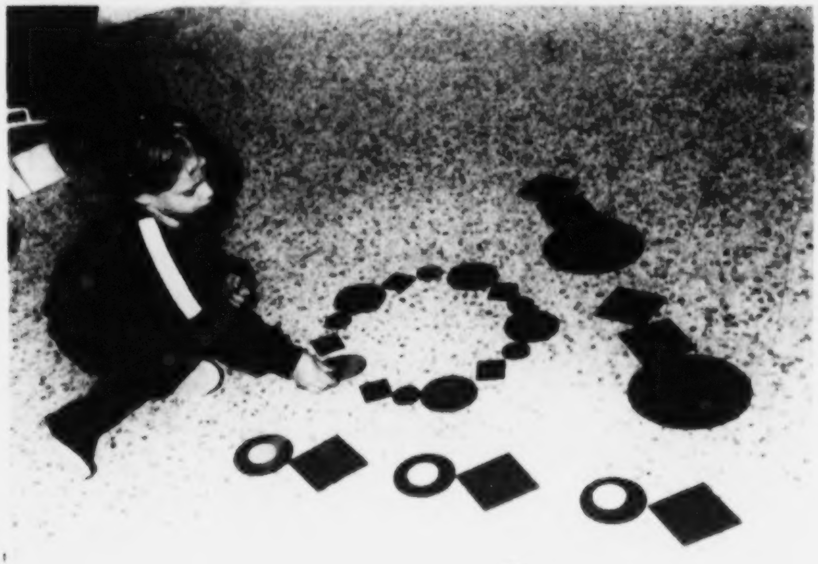
## V. CREATIVE PRODUCION



Open-ended creation of "patterns," after internalization of the concept (Unit 3)

Creation of horizontal and vertical lines (Unit 8)

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## OTHER ACTIVITIES

### * Visual Exactness

Measuring the radius of a circle (Unit 1)

Measuring the equal sides of a square (Unit 2)

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N

Measuring the
horizontal orientation
of a structure (Unit 6)

Measuring the
horizontal orientation
of an object (Unit 6)

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o

* Problem Solving

Creation of a big square from smaller squares of different sizes

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## III. IMPLEMENTATION

### A. PRESCHOOLS IN ISRAEL

Before discussing how the Agam Program is incorporated in Israeli preschools, it would be useful to give a brief account of early childhood education in Israel.

Israel's educational system is centralized through the Ministry of Education and Culture, which plans or approves all basic aspects of the educational enterprise: programs, buildings, teacher-training and teacher supervision. One consequence of this centralization is that preschool educational policy and standards are consistent throughout the country.

Israeli preschools are an indispensible aspect of Israeli life, especially in light of various factors: (1) the social status of women (a large percentage of Israeli mothers work outside the home), (2) the existence of an immigrant society (social integration is a high priority), (3) the Israeli lifestyle (which is, to a great degree, family-oriented) and (4) the high social value placed upon education.

While public education is compulsory only for 5-year olds, the overwhelming majority of Israeli children attend preschool classes from the age of 3-years old. These public classes are supported by the Ministry of Education and Culture, the municipalities, communal settlement (kibbutz and moshav) committees, and other public organizations; parents pay for only a part of the expenses. In large cities, private preschools exist and are totally supported by the parents

The typical preschool class is made up of about 20-30 children and is taught by a certified teacher along with 1-2 assistants. It is open from 8:00 a.m. until 12:30 p.m., 6 days a week. The daily routine incorporates three activity frameworks:

(a) the entire class -- via whole-group lessons, trips and parties,

(b) small-group work -- via teacher-led activities involving preplanned groups or random groups of children, and

(c) individualized work -- via activities adapted to the specific ability and development of the individual child.

In addition to open-ended play and exploration activities, preschool educators can choose from a variety of different programs, each dealing with different skills and a different field of knowledge. These programs include:

- a language program, which embraces the three functions of language: a tool for thinking, a means of expression and a means of communication,
- a mathematics program, which develops mathematical concepts and logical thinking abilities,
- a social sciences program, the main goal of which is to impart basic concepts of humanistic, civic and intellectual education,
- a story-telling program, whose aim is to develop imagination, feeling and thought, through the reading of fine children's literature.
- a program for the natural sciences (MATAL), geared to 5-year olds, which develops observation and thinking skills related to simple natural phenomena.
- the Magic Ring Program, also for 5-year olds, designed to develop emotional-social aspects of growth and
- various computer-based programs.

While these and other educational programs are designed for Israeli preschools, their actual use in any given class is contingent on a number of factors, e.g., the teacher's background and interests, the supervisor's orientation and guidance, the program's cost and the preschool's budget, etc.

Given the above framework of preschool education in Israel, how is Agam Program implemented in the classes?

## B. IMPLEMENTING THE AGAM PROGRAM

The Agam Program is well-integrated into the daily routine of the typical Israeli preschool.

As noted in the introduction, this program has been experimentally implemented in two 2-year cycles. In each of these cycles, efforts were concentrated on 4- and 5-year-old children. In addition, the Agam Program has been successfully implemented with 3- and 6-year olds as well.

The Agam Program fits well into the preschool framework, since its activities reflect the young child's physical and mental development; incorporated into the schedule are activities of movement and relaxation, games and learning activities. The program also fits well into the three activity frameworks mentioned above:

(a) The whole class. Often, the preschool teacher presents activities to the entire class, e.g. in identification activities and in group games. For example, in Units 1 ("Circle") & 2 ("Square"), the teacher introduces the large plastic circle and large plastic square, respectively, in front of all the children. Each time, she traces her index finder around the perimeter of the large plastic form; in the first case, the tracing is smooth and uninterupted, while in the second case, she calls attention to the difference by saying "boom!" each time her finger reaches a corner.

Another example is a visual discrimination activity in Unit 4 ("Circle and Square"). The preschool teacher spreads different combinations of circles and squares on the floor. On a board she presents one of the combinations. The children then walk between the different shapes to the sound of music. When the music stops, the children must stand quickly on the combination of shapes identical with the model.

(b) Small-group work. Most of the memory and reproduction activities are presented in small sub-groups. These activities are usually conducted around 11 a.m., during the daily outdoor recess. The teacher is free to work indoors with small groups, i.e., about 2-3 groups daily. Each group includes from 4-6 children.

In one of the memory activities, the teacher arranges 9-12 flash cards on the table. The teacher holds an identical stack of flashcards and sits opposite the children. She quickly shows them one of the cards. While all the children view the flashcard, only one child at a time is asked to identify the correct copy on the table. Sometimes, children are asked to identify from 2-4 memory cards presented rapidly in sequence.

The reproduction activities make use of a wide variety of different media, e.g., transparencies, plastic forms, construction paper, modeling clay, found objects and the children's own bodily activity.

(c) Individualized work. Activities involving the individual child usually take place in the "Agam Corner," a portion of the preschool dedicated to such activities. This area includes the manipulatives (e.g., the transparencies, plastic forms, construction paper, etc.), along with individualized tasks relating to the unit being studied.

Children have free access to this area throughout the day and they make use of it as they do with the other activity centers located in the preschool class (e.g., blocks, games, puppets area, etc.). For example, during Unit 3 ("Patterns"), students are invited to reproduce given patterns and make their own, in the Agam Corner.

It is important to note that the Agam Program is not time-intensive, from the preschool child's point of view. Each child is engaged in the program's activities for about 60-90 minutes per week.

## C. EVALUATION OF IMPLEMENTATION

During the first implementation and research cycle (1983-5), evaluation of implementation was undertaken in 4 preschools (Eylon et al., 1986). The current report, which deals with the second implementation and research cycle (1985-7), is based on implementation of the Agam Program in 25 preschools.

Outside of the fact that the second cycle involved about a six-fold increase in the number of participating preschools, the staff's conclusions are very similar. These conclusions relate to the program's (1) age suitability, (2) rate of progress, (3) compatability with the existing preschool curriculum, and (4) large-scale implementation.

1. Age Suitability. Implementation of the Agam Program was limited to children aged 3 to 6. Without exception, the program proved to be very appropriate and interesting to all these ages. This conclusion is based on the observations of the trained staff, as well as the feedback of the participating children and teachers.

The implementation was conducted with several groups, i.e., 4-6 year olds, who composed the 25 preschools participating in the main experiment; an experimental class of 3-year-olds, which participated for three consecutive years; and 6-year olds (first graders) who participated in development work with new units in the Agam Program.

2. Rate of Progress. As noted in earlier progress reports, the first two units took about two months each to complete; afterwards, the average rate increased to about one unit per month. Thus, as it presently exists, a two-year Agam Program (for 4-to 5-year olds) could be expected to cover about 12 of the 36 units. The implications of this fact are discussed in the recommendations.

3. Compatability with the Existing Preschool Curriculum. As described above, the Agam Program was successfully integrated within the existing daily framework of the Israeli preschool. earlier. Thus, the whole-class Agam Program activities fit into the existing time periods for whole-class activities. The small-group instruction usually takes place during the dailt recess period. Likewise, the activities geared to the individual child (via "The Agam Corner") fit into the existing schedule for free-choice activities. In short, the program fits well into the existing daily routine of the Israeli preschool.

The optimal integration of the Agam Program with the other preschool curricula was not immediate. The participating teachers, at first, placed more emphasis on the program, as is the case with the introduction of any new curriculum. However, as the teachers progressed in their learning about the content and didactics of the program, they also gave it the right emphasis. In particular, teachers who taught the program for the second or third time integrated it better, and with more flexibility, with the other preschool curricula.

4. Large-Scale Implementation. The six-fold increase in the number of participating preschools allowed the project staff to build a model of implementation on a larger scale. One conclusion is that the program can run well on a large scale, with regular preschool teachers and with children from a wide variety of different backgrounds.

## D. TEACHER TRAINING

The most essential aspect of the Agam Program's implementation is the teacher training. Given the unique characteristics of this curriculum, and the accompanying didactic requirements (see Chapter II), it is imperative that the participating preschool teachers receive adequate preparation, practice and supervision.

### 1. Components

Teacher training in the Agam Program consists of two major components: (a) teacher workshops (preservice and inservice) and (b) on-going supervision.

Teacher workshops are held on a regular basis. A 4-day preservice workshop occurs the summer before the start of the school year. Inservice workshops are held once every 6-7 weeks throughout the school year, and during the school vacations. These workshops are designed to prepare teachers to (a) understand the goals and rationale of the program and its activities, and (b) properly present the program in their respective preschools. The workshops are based on a wide variety of activities. The teachers hear lectures about different aspects of the Agam Program, from theoretical, research and practical perspectives; experience sample activities from the program; role-play in presenting various activities; and, with the trained staff, discuss didactic approaches and specific difficulties.

On-going supervision of the preschool teachers takes place throughout the school year. During the first year the rate is one visit every two weeks; during the second year, the rate is somewhat reduced, depending upon the progress of each preschool teacher. Each visit includes an observation of the preschool teacher as she presents the Agam Program, and a follow-up discussion between the teacher and her supervisor.

## 2. Content

The content of the teacher training in the Agam Program relates to the program's subject matter, didactics and guided teaching experience.

2.1 Subject Matter. Due to the unique nature of the Agam Program, it was important to provide the participating teachers with relevant theoretical background.

The subject matter of the program includes mathematical concepts that are often new to the teachers. Lectures and learning activities focused on an in-depth treatment of the program's specific visual concepts (e.g., circle, pattern, square, triangle, symmetry, etc.,); These concepts were presented from a geometrical perspective by experienced math educators from the Department of Science Teaching. The dual emphasis here was on the need for precision as well as on the value of using an intuitive approach in introducing these concepts.

Other lectures and learning activities dealt with the significance and explication of the program's goals (e.g., the significance of visual thinking; developing visual thinking; the development of symbolic thinking); these lectures were usually accompanied with structured visual tasks, to focus attention on different types of visual thinking. Attention was also given to types of visual thinking not explicitly developed in the Agam Program (e.g., spatial orientation, three-dimensional imagery, mental rotations).

2.2 Didactics. Principles underlying the teaching of the Agam Program have been described above (see Chapter II, section D). These principles are (a) a structured approach, (b) multiple modes of representation, (c) a cumulative presentation strategy, and (d) minimal use of verbal instruction.

Through the means of the workshops and the preschool visits, emphasis was placed on these principles. For example, in terms of a structured approach, the teachers learned about the rationale and use of the same activity categories for each unit (i.e., activities in identification, memory, reproduction, and reproduction from memory), the progression from activities involving the "abstract" concept those involving "concrete" examples, and the progression from non-graphic reproduction to graphic reproduction; also, they were taught to place emphasis on accuracy in developing the children's perception, memory and reproduction.

A special priority was placed on training the teachers to use a minimum of verbal instruction. This emphasis on non-verbal teaching is central to the conception and implementation of the Agam Program. The rationale for this emphasis, as described earlier, is that too much verbal instruction interfers with the development of a child's capacity to identify, absorb, manipulate and generate visual stimuli.

2.2 Guided teaching experience. In order to gain hands-on teaching experience, teachers were first asked to present activities within the context of the inservice workshops. Throughout the year, via the regular visits of supervisors to the preschools, the teachers gained additional guidance and feedback regarding their teaching of the Agam Program.

Since there were some aspects of the program which were difficult to implement (e.g., the minimal use of verbal instructions), micro-teaching techniques were employed in the inservice workshops. Micro-teaching involves (a) videotaping a teacher who presents a relatively short lesson, (c) reviewing the event, and (b) analyzing the event through guided discussion by a highly-trained facilitator. In the latter, attention is focused on specific issues, e.g., analysis of the goals of the activity, non-verbal teaching behavior, the giving of feedback, etc.

## E. EVALUATION OF TEACHER TRAINING

Evaluation of teacher training was undertaken by means of staff observations and teacher questionnaires.

At the end of their 2-year participation in the Agam Program, the overwhelming majority of teachers wrote that they were very pleased with the teacher training and they recommended to continue integrating the different elements of this training.

More specific comments relate to the three content areas of the teacher training: (1) didactics, (2) guided teaching experience, and (3) theoretical background.

### 1. Didactics

The preschool teachers were initially apprehensive about the structured and systematic nature of the Agam Program. They were fearful that such an approach would hinder the development of the children's creativity. The inservice workshops made it possible for the teachers to personally try out the creative activities in each unit. In their evaluations, the teachers expressed enthusiasm about the wealth of innovation and imagination incorporated in the presentation of each visual concept; moreover, their apprehension was replaced with the experience that the Agam Program develops children's creativity.

Another initial apprehension of teachers involved the program's progression from the "abstract shape" to the "concrete object". At first, this sequence seemed counter-intuitive. However, the teachers observed that the children found no difficulties with this approach. In effect, children's initial exposure to an "abstract" visual concept, in the Agam Program, is based on a long history of informal exposure to concrete visual objects, in their everyday lives.

But by far, the biggest obstacle faced by the teachers was verbal: they found it very difficult to keep their verbal interactions with the children to a minimum. At first, many teachers found this new approach unnatural and even expressed opposition. With time, however, the teachers changed. They saw the positive reactions of their children to this non-verbal emphasis and they softened their opposition. This attitude change, based upon personal experience, is summarized by one teacher as follows:

> "During the first days of the inservice training, the program seemed very strange to me. In practicing the activities, we had to talk very little, while for years we had been used to talking to the child as much as possible, in order to enrich his language and to teach him to speak with correct sentence structure. Now, in the Agam Program, the opposite is right; everything is done through movement rather than through speech, and, lo and behold, the children understand the language of movement and eyes."

This new and experience-based awareness of visual communication increased with time and affected other areas of the teachers' preschool work. Another teacher commented that:

> "The program contributed to the variety of communication in the kindergarten -- verbal communication makes way for visual communication -- I realized that words do not have to be attached to a visual message nor does the latter have to be explained over and over again; the visual object speaks for itself. This new concept serves me as a guiding principle in other areas outside the program."

During the two years of implementation, several classrooms were intensively observed. It was clear that, as time progressed, some teachers overcame their initial apprehensions and became both comfortable and skilled in the use of non-verbal messages.

Nonetheless, even after a year's work with the program, many teachers used too many verbal messages. Therefore, in the beginning of the second year, the "microteaching" technique was initiated. As described in the last section, this technique is based on guiding teachers in visually of their own teaching, visual messages and improved their work with the children.

It must be pointed out that success in emphasizing visual communication, during the Agam Program's implementation, is also a function of a teacher's personality, including her inclinations and willingness to change. Thus, there were some teachers -- albeit a small minority -- who found it difficult to accept this approach even after working in the program for two years.

Our recommendation is that it is important to work intensively on the subject of visual messages, through microteaching sessions in the teacher inservice workshops, as well as through regular, directed teacher guidance in the preschools.

Another important recommendation relates to the optimal preservice teacher training. It would be much more efficient and cost-effective if a visual education course would be given to all preschool student teachers via the teachers colleges. Such a course would give these teachers a valuable "headstart" in teaching the Agam Program.

One of the teachers' recommendations, in the area of didactics, was to develop additional ways for them to check how well children internalized the various concepts. One suggestion was to develop various worksheets, for use by the children in the Agam Corner.

### 2. Guided Teaching Experience

In their evaluations, the preschool teachers attached special importance to the personalized and regular preschool visits of the Agam Program supervisors. These visits, which included the opportunity for teachers to discuss their own difficulties and suggest new ideas, were appreciated by all the participating teachers. One of their recommendations was for the supervisors to visit the preschools more frequently, especially during the first year.

From the point of view of the Agam Project staff, these guided visits were extremely important. Not only did they make it possible to provide individualized attention to each teacher, but they provided opportunities to evaluate each teacher's understanding and implementation of the Agam Program. As a result, the visits also provided an important feedback loop in helping determine the specific content of each inservice workshop. Thus, common teacher difficulties and/or areas of interest could be identified and included in an uncoming workshop. In this way, the guided visits made the inservice workshops more responsive to the development and needs of the participating teachers. It is worth noting that such supervision was more intensive in the first year and less so the following year.

Teachers stressed the value of directed teaching experiences in the inservice workshops. Also, many of the teachers recommended instituting reciprocal visits of teachers to each other's preschools, so that they would be able to observe their colleagues actively teach the program.

Thus, the most essential and indispensible aspect of the teacher training effort was the teacher's own personal experience implementing the Agam Program, guided by the trained staff. This experience is vital because the visually-oriented approach of the Agam Program is both unique and difficult to implement without adequate teaching practice.

### 3. Theoretical Background

In their evaluations, the teachers commented that the lectures on various theoretical topics were essential for understanding the program in depth. As an example, teachers felt it was important for them to receive an accurate explanation of various geometrical concepts from an expert dealing in this area; treatment of this theoretical aspect contributed to their confidence in the classroom and widened their general knowledge.

Several teachers recommended that an annotated bibliography should be provided for each lecture. Interest was also expressed in adding new lecture topics, such as the biological processes connected with visual perception.

## 4. Summary

In general, the preschool teachers in the Agam Program began with a number of hesitations. They were wary of the program's structure, fearing that this might dampen the children's creativity. Teachers were also doubtful about the program's focus on progressing "from the abstract to the concrete," in presenting the visual concepts. Another fear was that the Agam Program would come at the expense of other programs and activities. Most significantly, the beginning teachers found it difficult to accept the program's emphasis on giving visual messages, with a minimal use of verbal instruction.

A succinct summary of the teacher training evaluation is that the training alleviated all of these fears and hesitations. This training -- which included an integration of different approaches -- was viewed as extremely valuable, both by the teachers as well as by the Agam Project staff. Clearly, it was vital to the program's successful implementation in the preschools.

# PART 2: RESEARCH

## IV. RESEARCH METHODOLOGY

### A. RESEARCH ISSUES

As noted in the previous sections, the Agam Program may be described as non-conventional, if not unique, in its educational goals, didactic approach and target population.

Thus, research on the Agam Program had several goals:

1) to evaluate the program's implementation (see Chapter III),

2) to assess the cognitive outcomes of the program, including the development of visual skills, intelligence and creativity;

3) to assess the affective outcomes of the program,

4) to explore other possible contributions of the program beyond its professed aims.

### B. RESEARCH DESIGN

In order to address the above research issues, the staff of the Agam Project adopted a research design which included qualitative as well as quantitative research methodologies. These different methods were viewed as complementary in nature. The staff's overall goal was to integrate the data gained by each of these types of methods, in relating to each of the research questions posed above.

#### 1. Qualitative Methods

In addition to the quantitative methods described below, the project's research included naturalistic observations, as well as interviews and questionnaires. The following paragraphs present the rationale for including these methods, as well as an account of the objectives and process of the naturalistic observations.

1.1 Rationale. Every serious research work is based upon a research paradigm. Our use of qualitative research methods is based upon several assumptions. One assumption is that the field under investigation is very complex and that certain variables may be either unknown or highly interdependent. Thus, the danger exists that these variables would be neglected by research based upon preconceived hypotheses.

A second assumption is that it is important to keep track of "what is actually happening" during the Agam Program's implementation. This assumption posits the possible existence of important "side effects," i.e., outcomes of the program which were unspecified by the program's designers. In a program as unusual as the Agam Program, these unexpected effects -- relating to the teachers as well as the students -- could be at least as significant as the program's explicit goals.

Our third assumption was that it was important for the Agam Project's staff to understand and document the program, "from an insider's perspective," i.e., from the view of students and teachers. Using methods which helped us see the Agam Program from the inside helped us better understand this program and convey our understanding to others.

1.2 *Naturalistic Observations*. There were several specific objectives in conducting observations in the preschools:

(a) *The Program*. What behaviors illustrate the advantages and disadvantages of the program?

(b) *Cognitive Aspects*. What behaviors illustrate interesting and/or important cognitive strategies which children use in the program (e.g., visual memory, graphic representation, use of key concepts, etc.)

(c) *Affective Aspects*. What behaviors illustrate the likes and dislikes of the students and teachers, relating to the specific activities and content of the program?

(d) *Teaching*. What behaviors illustrate effective and ineffective teaching strategies, in presenting the Agam Program?

(e) *Specific Children*. What behaviors can teach us how the program is received differently by different children? What children might we follow over a period of time?

The process of conducting these observations involved a number of steps:

* *Step 1*: *The Observation*. Preferably, a team of two staff members made each observation. The goal was to record, as accurately as possible, what was actually happening. The observer was careful to write his or her reactions, assumptions and ideas as separate from the actual observation.

* Step 2: Formal Protocol. After the observation, a written protocol of the observation was produced by the observation team.

* Step 3: Summary Sheet. On the same day, the observer(s) looked over the protocol and tried to categorize relevant information in the summary sheet. This summary was organized into two parts: summary of the observations (according to the categories listed above), and observer comments and hypotheses regarding these observations.

* Step 4: Re-Reading. A "neutral" individual (one who was not involved in the observation) re-read the protocol and summary sheet. This individual would then discuss his or her comments with the original observer(s). Sometimes such a discussion would uncover new relationships and hypotheses.

* Step 5: Review By Staff. After the above steps, the written protocol and summary sheet were reviewed by the staff of the Agam Project. At staff meetings, issues raised by the observation would be discussed.

During the first year of the research, emphasis was placed on wide-focused descriptive observations. The intent was to identify interesting patterns relating to the project's research questions, simply by objectively observing what happened in the preschools during the presentation of the Agam Program's activities. Later, based upon these wide-focused observations, the emphasis shifted to focused observations and then to selected observations.

In a number of instances, these observations raised hypotheses andissues that were studies by other methods of inquiry, such as individualized tests (e.g., see Chapter VII), questionnaires, and structured interviews (see Chapter VIII)..

## 2. Quantitative Methods

The following section describes the sample and cognitive tests of the 2-year experiment.

2.1 Sample. An experimental versus comparison group design was used to measure the effect of the Agam Program. Initially, 51 nursery classes were chosen to participate in the experiment. These classes were arranged in pairs so that within each pair the classes were matched on geographic location (i.e., they were serving the same populations), and on religious orientation (i.e., within either the "religious" or "nonreligious" school frameworks). The unequal number of classes derives from the fact that two very small classes in one kibbutz were matched with one larger class in another kibbutz.

From this sample, 25 classes, one of each pair, were assigned randomly to the experimental group which received instruction in the Agam Program. The other 26 were used as comparison classes. For technical reasons one experimental and one control class dropped out of the experiment. As a result, the final sample at the beginning of the experiment consisted of 24 experimental and 25 control classes (313 and 334 children, respectively).

The children that were studied were all the 4-year-olds in the classes chosen, i.e., those who were 4 years old by December 1985. These children were tested and followed up over the 2-year implementation period.

The children in the experimental preschools studied and did group work in the Agam Program about three times a week, 20-30 minutes each time. Small-group activities took place while the other children in the class played outdoors. Other activities took place during the arts and crafts hour and still others were included in circle time. During the first year, the average experimental class worked on Units 1 through 6 of the Agam Program, (see Chapter II). During the second year, the average class worked on units 7 through 12 (two classes managed to work also on Unit 14).

Six experimental classes (no. 25, 31, 34, 36, 44, and 45 as listed in Tables 4.1 and 4.3) did not study the Agam Program in the second year for various technical reasons. Children in the comparison preschools received no training in the Agam Program. In other words, these children enjoyed more uninterrupted outdoor play, more free and unstructured arts and crafts activities and, in general, a freer and less structured visual experience. This experimental design afforded the opportunity to test an alternative popular hypothesis which maintains that not interfering with the child will result in his greatest development, while providing him with systematic teaching can only be harmful.

2.2 Cognitive Tests. The cognitive tests administered within this experiment are given in Table 4.1. Three tests of intelligence were administered to measure the effect of the Agam Program on intelligence. The Coloured Progressive Matrices (CPM) (Raven, 1977) and the Goodenough-Harris Draw-a-Man Test (Harris, 1963) were administered to all children at the beginning as well as at the end of the 2-year implementation period. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Lieblich, 1979) was administered to a subsample of the children at the beginning of this period.

The following additional measures were used during the first year (see Tables 4.2 and 4.4). The drawings created by each child in the arts and crafts hour during one-week's period were collected for study of the Program's effects on creativity. The children were also requested to create a free drawing of "a child doing something that makes him happy". A test somewhat misleadingly called "Pretest", that was actually administered in April and May of the first school year, i.e., after several months of study in the Program, tested transfer effects of the program in various visual skills. Two tests, "Circle and Square" and "Ornaments", were administered during the first year after the children finished the units of the same names. About half the classes were given a short version of the Ornaments Test. These two tests tested visual skills and concepts related to those taught in these units. The "Summary Test 1986" was administered at the end of the first year; it tested various visual skills.

The following measures were used during the second year (see Tables 4.3 and 4.5). The "Pretest" was administered again, this time towards the end of the experiment, during the month of June 1987, and intended as a sort of "posttest." The test "Orientations" measured the effects of units 6 through 10 (see Table 2.1). The Coloured Progressive Matrices (CPM) was administered individually for a second time at the end of the second year as a posttest. This was the case also for the other intelligence test, the Draw-a-Man test. The drawings created by the children in the arts and crafts hour during one whole week were again collected at the end of the second year to study the effect of the Agam Program on artistic work outside of the Program. A free drawing of "a child doing something that makes him happy" was also collected from all children at the end of the second year.

Other tests for the second year were the "Summary Test 1987" and the "Individual Test" that was administered individually to a subsample of children. The former test was mainly intended to measure cognitive transfer effects of the Agam Program; it was administered to small groups of 4-5 children in two separate daily sessions. The "Individual Test" included selected items from Torrance's test, Thinking Creatively with Pictures (Figural Booklet A), one of the Torrance Tests of Creative Thinking (Torrance, 1974) and some other tests.

Table 4.1

Summary of Tests Administered to the
Experimental and Comparison Children
1985-1987.

| Test Instruments | Experimental Classes (N=313) | Comparison Classes (N=334) |
|---|---|---|
| 1985-1986 | | |
| Beginning of year baseline tests | | |
| Intelligence tests | | |
| Raven Progressive Matrices | 302 | 322 |
| WPPSI | 53 | 41 |
| Draw-a-Man | 252 | 268 |
| Creativity | | |
| Drawing Collection | + | + |
| Free Drawing | + | + |
| Concurrent tests | | |
| Cognitive visual skills tests | | |
| "Pretest" | 183 | 174 |
| Circle/Square | 138 | 133 |
| Patterns | 140 | 119 |
| Patterns Short Test | 146 | 141 |
| End of first year tests | | |
| Summary test | 264 | 251 |
| 1986-87. | | |
| Concurrent tests | | |
| "Pretest" | 117 | 78 |
| Orientations | 123 | 82 |
| End of second year tests | | |
| Summary Test | 160 | 97 |
| Individual Test | 65 | 54 |
| Intelligence tests | | |
| Raven Progressive Matrices | 210 | 189 |
| WPPSI (1 item in Individual Test) | 65 | 54 |
| Draw-a-Man | 156 | 103 |
| Creativity | | |
| Free drawing | + | + |
| Drawing Collection | + | + |
| Torrance (1 item in Individual Test) | 65 | 54 |

Table 4.2

Tests Administered to the Experimental Classes in 1985/86

| Class | Code | N | CPM | WPPSI | Draw -a- Man | Drawing Collection | Free Drawing | Pretest | Circle Square | Patterns | Patterns Short Test | Summary Test 1986 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 21 | 18 | 17 | 5 | | + | + | 17 | 18 | 16 | | 16 |
| 2. | 22 | 8 | 7 | | 8 | + | + | 8 | | | 8 | 8 |
| 3. | 23 | 11 | 9 | | 11 | + | | 9 | | | 10 | 10 |
| 4. | 24 | 10 | 10 | | 10 | + | + | 10 | | | 10 | 10 |
| 5. | 25 | 11 | 11 | 4 | 11 | + | | 11 | 10 | 10 | | 10 |
| 6. | 26 | 26 | 26 | | 25 | + | + | | | | 20 | |
| 7. | 27 | 14 | 14 | | 13 | + | | 12 | | | 14 | 14 |
| 8. | 28 | 15 | 15 | 4 | 14 | + | | 14 | 14 | 13 | | 14 |
| 9. | 29 | 18 | 18 | 6 | 16 | + | + | 15 | 14 | 14 | | 15 |
| 10. | 30 | 13 | 13 | | 12 | + | + | | | | 14 | 13 |
| 11. | 31 | 10 | 9 | 3 | 10 | + | | 9 | 9 | 9 | | 9 |
| 12. | 32 | 14 | 14 | 5 | 12 | | | 13 | 11 | 14 | | 14 |
| 13. | 33 | 11 | 10 | | | | | | | | 10 | 10 |
| 14. | 34 | 7 | 7 | 3 | 7 | + | + | 6 | 7 | 6 | | 6 |
| 15. | 35 | 8 | 8 | | 7 | + | | | | | 8 | 8 |
| 16. | 36 | 12 | 12 | 4 | 11 | + | | 11 | 12 | 11 | | 9 |
| 17. | 37 | 12 | 12 | | 12 | + | | | | | 10 | 10 |
| 18. | 38 | 17 | 16 | | 15 | + | | | | | 16 | 16 |
| 19. | 39 | 16 | 16 | 9 | | + | + | 16 | 14 | 16 | | 15 |
| 20. | 40 | 19 | 18 | 5 | 18 | | + | 17 | 17 | 17 | | 18 |
| 21. | 41 | 16 | 14 | 5 | 15 | + | | 15 | 12 | 14 | | 13 |
| 22. | 43 | 14 | 13 | | 12 | + | | | | | 13 | 13 |
| 23. | 44 | 7 | 7 | | 7 | + | | | | | 7 | 7 |
| 24. | 45 | 6 | 6 | | 6 | + | | | | | 6 | 6 |

Table 4.3

Tests Administered to the Experimental Classes in 1986/87

| Class | Code | Pre-test | Orientations | CPM | Draw-a-Man | Drawing Collection | Free Drawing | Individual Test | Summary Test 1987 |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 21 | 12 | 15 | 18 | 19 | + | + | 5 | 13 |
| 2. | 22 | | | 18 | 18 | + | + | | |
| 3. | 23 | | | | | + | | | |
| 4. | 24 | 10 | 9 | 11 | 11 | + | + | 6 | 8 |
| 5. | 25 | 8[a] | 9[a] | 9 | 9 | + | + | | 9[a] |
| 6. | 26 | | | 23 | 21 | + | + | | 22 |
| 7. | 27 | | | | | + | | | |
| 8. | 28 | 13 | 9 | 15 | | + | | 6 | 12 |
| 9. | 29 | 11 | 11 | 15 | 18 | + | + | 6 | 14 |
| 10. | 30 | | | | 10 | + | + | | |
| 11. | 31 | | | | | + | | | |
| 12. | 32 | 14 | 14 | 14 | | + | | 6 | 14 |
| 13. | 33 | | | 12 | | + | | 7 | 7 |
| 14. | 34 | | | | | | | | |
| 15. | 35 | | | 3 | | + | | 5 | 4 |
| 16. | 36 | | | | | + | | | |
| 17. | 37 | | | | | + | | | |
| 18. | 38 | | | | | + | | | |
| 19. | 39 | 13 | 14 | 19 | 16 | + | + | 6 | 14 |
| 20. | 40 | 19 | 20 | 19 | 15 | + | + | 6 | 20 |
| 21. | 41 | 17 | 22 | 19 | 19 | + | | 6 | 15 |
| 22. | 43 | | | 15 | | + | | 6 | 8 |
| 23. | 44 | | | | | + | | | |
| 24. | 45 | | | | | | | | |

[a] These children were transferred to class 24 in 86/87.

Table 4.4

Tests Administered to the Control Classes in 1985/86

| Class | Code | N | CPM | WPPSI | Draw-a-Man | Drawing Collection | Free Drawing | Pretest | Circle Square | Patterns | Patterns Short Test | Summary Test 1986 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 61 | 18 | 18 | 5 | 18 | + | + | 18 | 18 | 16 | | 15 |
| 2. | 62 | 14 | 12 | | 13 | + | + | 12 | | | 8 | 8 |
| 3. | 63 | 10 | 9 | | 10 | | + | 9 | | | 9 | 9 |
| 4. | 64 | 10 | 10 | | 10 | | | 10 | | | 9 | 9 |
| 5. | 65 | 14 | 14 | 4 | 12 | + | | 11 | 13 | 12 | | 14 |
| 6. | 66 | 12 | 12 | | 12 | + | | | | | 13 | |
| 7. | 67 | 14 | 14 | | 13 | + | | 13 | | | 14 | 14 |
| 8. | 68 | 17 | 17 | 4 | 17 | + | + | 15 | 16 | 16 | | 14 |
| 9. | 69 | 12 | 12 | 3 | 12 | + | | 10 | 11 | 10 | | 11 |
| 10. | 70 | 17 | 17 | | 17 | + | | | | | 12 | 15 |
| 11. | 71 | 11 | 11 | | 10 | + | | 11 | 10 | 8 | | 10 |
| 12. | 73 | 17 | 17 | | 18 | + | | | | | 12 | 12 |
| 13. | 74 | 21 | 20 | 7 | 20 | + | + | 19 | 20 | 12 | | 12 |
| 14. | 75 | 18 | 18 | | 17 | + | | | | | 12 | 12 |
| 15. | 76 | 15 | 14 | 5 | 15 | + | | 14 | 15 | 14 | | 15 |
| 16. | 77 | 19 | 16 | | 19 | + | | | | | 17 | 17 |
| 17. | 78 | 13 | 13 | | 12 | + | | | | | 10 | 10 |
| 18. | 79 | 13 | 13 | 5 | 11 | + | + | 13 | 12 | 12 | | 10 |
| 19. | 80 | 20 | 17 | 5 | | + | + | | | | | |
| 20. | 81 | 14 | 14 | | | | | 13 | 13 | 13 | | 13 |
| 21. | 82 | 9 | 8 | | | + | | 6 | 5 | 6 | | 6 |
| 22. | 83 | 9 | 9 | | | | | | | | 9 | 9 |
| 23. | 84 | 5 | 5 | | | | | | | | 5 | 5 |
| 24. | 85 | 4 | 4 | 3 | 4 | + | | | | | 3 | 3 |
| 25. | 86 | 8 | 8 | | 8 | + | | | | | 8 | 8 |

Table 4.5

Tests Administered to the Control Classes 1986/87

| Class Code | Pre-test | Orientations | CPM | Draw-a-Man | Drawing Collection | Free Drawing | Individual Test | Summary Test 1987 |
|---|---|---|---|---|---|---|---|---|
| 1. 61 | 10 | 12 | 17 | | + | | 6 | 10 |
| 2. 62 | | | 16 | 16 | + | + | | |
| 3. 63 | | | 15 | 17 | | + | | |
| 4. 64 | 7 | 7 | 8 | 7 | | + | 5 | 7 |
| 5. 65 | | | | | + | | | |
| 6. 66 | | | | | | + | | |
| 7. 67 | | | | | + | | | |
| 8. 68 | 14 | 15 | 18 | 17 | + | + | 6 | 14 |
| 9. 69 | 7 | 7 | 15 | | + | | 6 | 5 |
| 10. 70 | | | | | + | | | |
| 11. 71 | | | | | + | | | |
| 12. 73 | | | 14 | | + | | 3 | |
| 13. 74 | | | | | + | + | | |
| 14. 75 | | | 14 | | + | | 5 | 16 |
| 15. 76 | | | | | + | | | |
| 16. 77 | | | | | + | | | |
| 17. 78 | | | | | + | | | |
| 18. 79 | 10 | 10 | 23 | 13 | + | + | 6 | 10 |
| 19. 80 | 18 | 19 | 19 | 20 | + | + | 5 | 14 |
| 20. 81 | 12 | 12 | 16 | | | | 6 | 12 |
| 21. 82 | | | | 3 | + | | | |
| 22. 83 | | | 14 | 10 | + | | 6 | 9 |
| 23. 84 | | | | | + | | | |
| 24. 85 | | | | | + | | | |
| 25. 86 | | | | | + | | | |

# V. RESULTS: BASIC VISUAL SKILLS AND CONCEPTS

This chapter describes the results obtained from the analysis of some of the cognitive tests. The focus is on tasks designed to probe acquisition of basic visual concepts and skills. The next chapter discusses results involving transfer of these concepts and skills.

As described in Chapter II, the Agam Program integrates the learning of concepts and skills. The various visual skills are trained repeatedly within the context of each concept. This structure of the program is reflected in the description of the results. We look at the data from two points of view: the view of basic visual skills and the view of basic visual concepts.

Accordingly, this chapter has three parts: the tasks and their analysis, results on basic visual skills, and results on basic visual concepts.

## A. THE TASKS AND THEIR ANALYSIS

### 1. The Tasks

As described in the previous chapter, throughout the two years, the children were given seven written tests examining the acquisition of visual concepts and skills. The tasks included tasks directly trained by the program and transfer tasks. Table 5.1 categorizes the test tasks in relation to concepts and skills. The inner block of tasks includes the basic-level tasks, while the rest of the Table includes transfer tasks with respect to concepts, skills or both. A detailed description of each task will be given in conjunction with the results. Examples of the written tests are given in Appendix 2.

There were three types of tasks in the written tests:

a) Multiple-choice tasks. Children had to identify one or more correct answers among several distractors (e.g., children were asked to identify all the horizontal vertical and oblique lines in a drawing).

b) Open-ended tasks. Children were asked to generate answers. In these tasks, there were many correct answers, more than any one child gave (e.g., children were asked to identify many different examples of squares in the classroom).

c) Construction tasks. Children had to reproduce a stimulus or to generate some drawing, according to

Table 5.1: Categorization of the task by the main concepts and the processes that they examinbe. The inner block includes tasks probing basic concepts and processes , the rest include transfer tasks. The list of tests appears below, the letters identify the tests and the numbers refer to the item number in the test.

| CONCEPT / SKILL | CIRCLE | SQUARE | CIRCLE-SQUARE | PATTERNS | ORIENT-ATIONS | OTHER |
|---|---|---|---|---|---|---|
| ***BASIC:*** | | | | | | |
| **IDENTIFICATION** | | | | | | |
| Geometrical simple | A1 | A2 | | B5 | C1 | |
| Geometrical complex | | | E2 | | | |
| Picture | | | | | C2 | |
| Environment | A11 | A12 | | B7 | C9 | |
| **MEMORIZATION** | | | | | | |
| Geometrical | A6,A7 | A8,A9 | | B2,B3 | C4,C5 | |
| Picture | | | | | | |
| **REPRODUCTION** | | | | | | |
| Copy | A3 | A4 | E1 | | C8 | |
| Copy on grid | | E5 | E3 | | C3,E4 | |
| Complete | | | | B6,D2 | C6 | |
| From memory | A10 | | | B4 | | |
| ***TRANSFER:*** | | | | | | |
| **COMPLEX VISUAL PROCESSES** | | | | | | |
| IDENTIFICATION | | | | | | |
| Geometrical | | | | | | D1,F8,F11 |
| Picture | | | | | | D4,F7,F10<br>F12 |
| MEMORIZATION | | | | | | D5,D6,E6 |
| REPRODUCTION | | | | | | D3,F4,F5<br>F6,F9 |
| FINE MOTOR SKILLS | A3 | A4,F1 | | | | F2,F3 |
| **VISUAL LEARNING** | | | | | C7 | |
| **MATHEMATICAL READINESS** | all basic tasks | all basic tasks | all basic tasks | all basic tasks | all basic tasks | F8 |
| **CREATIVITY** | | A5 | | B1 | G1 | |

Tests:

| | | |
|---|---|---|
| A-Circle and Square | D-Pretest (Comparative test) | G-Individual Test |
| B-Patterns | E-Summary Test 1986 | |
| C-Orientations | F-Summary Test 1987 | |

prespecified criteria (e.g., children were asked to draw a circle between two concentric circles).

To code the construction tasks, a detailed categorization scheme was developed to capture important features of the children's drawings. For example, in the case of reproducing several intersecting forms, the following aspects were included in the categorization scheme: (1) the number of recognizable forms, (2) the quality of drawing each form according to its characteristics, (3) the relative positions of the various forms, (4) the size of the forms, and (5) some global measures, e.g., the resemblance of the reproduced drawing to the original one, and whether there was any attempt at synthesizing the elements of the drawing (see Appendix 3 for an example of a categorization scheme).

The categorization schemes were developed on the basis of a small subsample of the children's drawings. The schemes were then tried out on another subsample of drawings, and the necessary corrections were introduced. Only when the scheme seemed to be reproducible by independent coders were all the drawings coded. Samples were chosen to test for reliability.

## 2. Analysis

In addition to the distributions of the various categories, "global" measures were also obtained for each task, in order to permit statistical evaluation of differences between the experimental and comparison groups. The way in which the global measures were calculated depended on the type of tasks, as described above. In the multiple-choice tasks, in which children had to choose and mark some of the stimuli according to a certain criterion, two measures were computed: (a) the percentage of correct answers and (b) a "compound measure" that takes into account both correct and incorrect answers. This latter value was computed by using the formula:

$$\left(\begin{array}{l}\text{(No. of child's correct answers)/}\\ \text{(No. of items marked by the child)}\end{array}\right) \times \left(\begin{array}{l}\text{\% correct}\\ \quad\text{answers)}\end{array}\right.$$

This measure takes into account both the correct and incorrect answers. For instance, if a child would mark all the correct answers and would make no mistakes, the score would be 100%. But if the same child would mark some incorrect answers, the score would be less than 100%.

The open-ended tasks involved an undetermined number of correct answers. In these tasks, both the total number of answers and the number of correct answers were computed.

In the construction tasks, the child's performance was judged on the basis of a categorization scheme and the global measure was obtained by weighing the various categories. The specific weighing scheme will be described with respect to each task.

For each of these measures, an ANCOVA (analysis of covariance) with blocking was performed. A composite IQ score served as the covariate. This score was computed as an average of each child's scores on up to 3 IQ tests: the coloured progressive matrices (Raven et al., 1977), the WPPSI (Lieblich, 1979), and the Goodenough-Harris Draw-a-Man Test (Harris, 1963). The child's class served as the blocking variable (classes were matched as described in the design section, see Chapter IV); and the experimental and comparison groups defined the treatment variable.

The ANCOVA was performed in two stages: First we tested the interactions between the variables. Then, we performed an analysis of covariance. Significant interactions between dependent variables with block or intelligence will be indicated.

We report the results about the measures in a standard form: a histogram that depicts the adjusted means for the relevant measures, along with a table that provides the level of statistical significance for the contribution of the control variables (IQ, block and treatment) to the variance of the relevant measure. The statistical significance of the treatment is based on one-tailed tests.

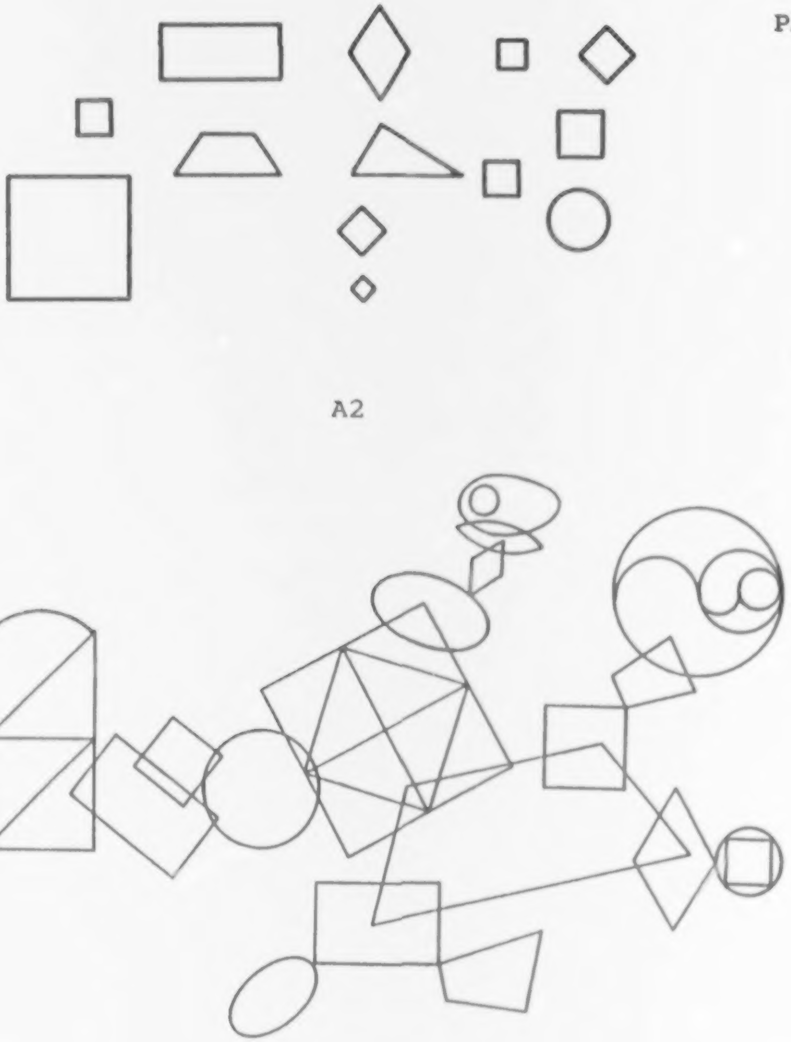
The next section describes the results for the basic visual skills (i.e., identification, memorization and reproduction at the basic level). Afterwards, an analysis of the results is presented in terms of the basic concepts.

## B. BASIC VISUAL SKILLS

### 1. Identification Tasks

The skill of identification was tested by asking children to identify instances of a concept in three different contexts, i.e., in (1) drawings of geometrical forms, (2) realistic pictures and (3) the class environment.

1.1 Geometrical forms. All the stimuli in this category consisted of drawings of geometrical forms including examples and nonexamples of a given concept. The child had to identify the examples and mark them. Figure 5.1 shows examples of the types of display in the tasks: (a) a simple display where the forms were drawn separately and (b) a complex display in which the forms intersected each



A2

E2

Figure 5.1
Identification of Geometrical Forms
Children were asked to identify examples of geometrical forms in a simple display (A2), and a complex display (E2).

other.

Figures 5.2a and 5.2b present findings for the simple display in the geometrical context. The results include both the simple and compound measures that were described previously.

The results show a significant difference between the experimental and comparison groups for the concepts "square", "patterns" and "orientations," but not for the concept "circle." The most pronounced difference is in the concept of "patterns."

Identification of the concept in a complex geometrical context was tested only for the circle and square concepts (see Figure 5.1 for the task). Figure 5.3 presents results for the simple and compound measures. Significant differences were found for both concepts. More details about the nature of students' errors can be found in section on circle and square.

1.2 Realistic picture. Figure 5.4 depicts the task given to test identification of the various orientations in a picture. The children were asked to mark all the segments that are horizontal, vertical and oblique by three different colours. For each orientation, the simple and compound measures were computed.

Figures 5.5a and 5.5b present the adjusted means of both measures for each orientation across the objects in the picture. Table 5.2 presents the adjusted means of correct answers for each orientation and each object in the picture.

The results show a significant effect for the three orientations. These results support the claim that the children in the experimental group have developed a skill of analysis -- being able to identify the geometrical concepts in a complex stimulus which is not purely geometrical. The next section examines the skill of identification in an even more realistic context, i.e., in the class environment.

The results also show that for the curved segments in the picture (e.g. the trunk of the tree) there were no differences in false identifications between the groups. The implications of this result will be discussed later.

1.3 Classroom environment. These tasks were administered individually to each child at the end of the respective written test. The child was asked to point at instances of the tested concept in the classroom environment. It should be stressed that due to the sampling process (matching), there were no differences between the environments in the

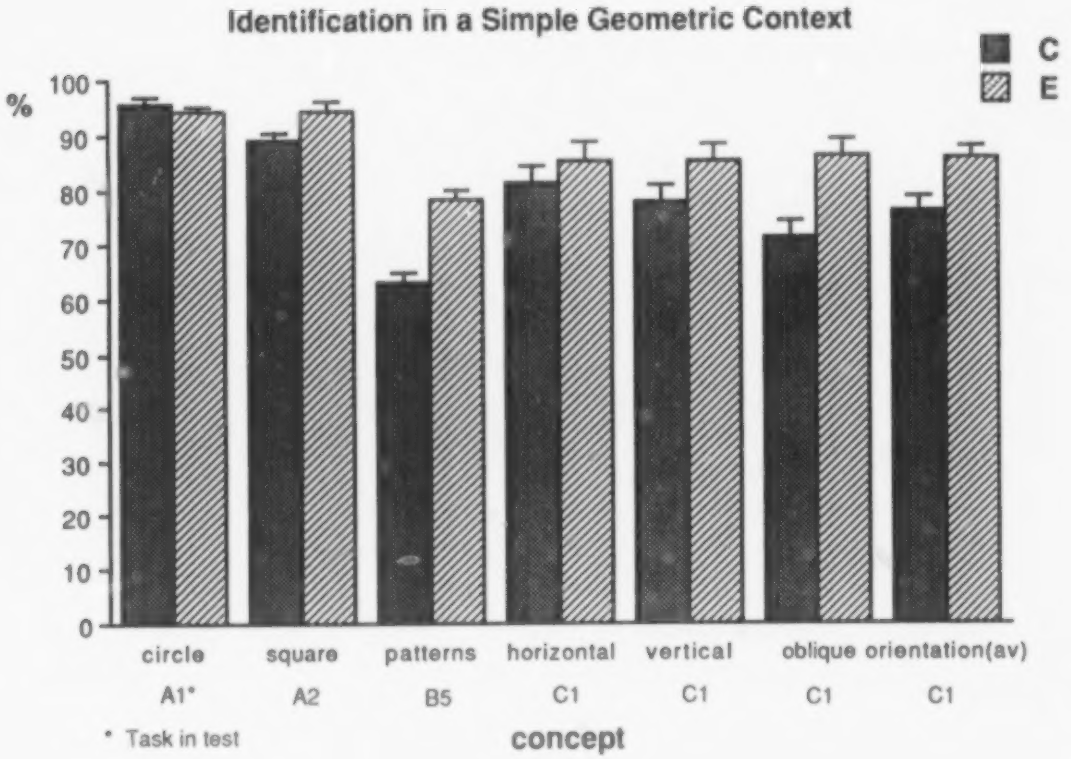


Figure 5.2a: Mean percentages of correct answers adjusted for IQ and block. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle** | 125 | 107 | 0.0001 | ns | ns |
| **Square** | 125 | 107 | 0.004 | ns | 0.007 |
| **Patterns** | 238 | 246 | 0.0001 | 0.0001 | 0.00005 |
| **Orientation(av.)** | 77 | 82 | 0.03 | ns | 0.005 |
| **Horizontal** | 77 | 82 | 0.01 | ns | ns |
| **Vertical** | 77 | 82 | ns | ns | ns |
| **Oblique** | 77 | 82 | ns | ns | 0.0005 |

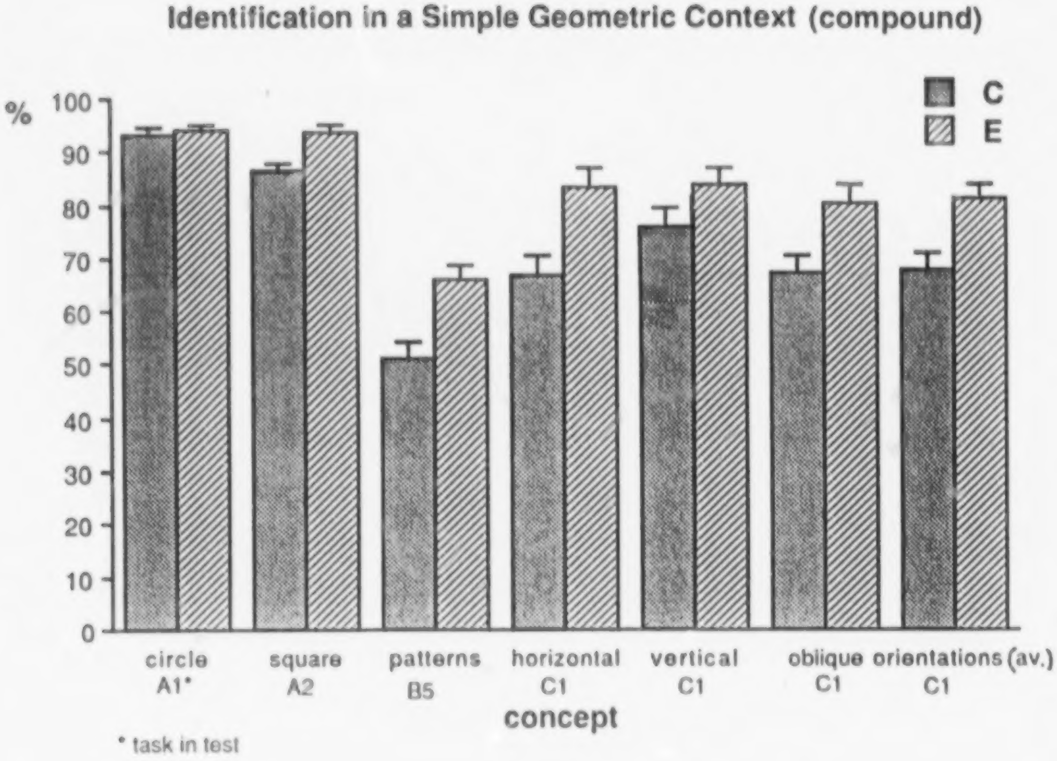


Figure 5.2b: Means of the compound measure adjusted for IQ and block. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle** | 125 | 107 | 0.0001 | ns | ns |
| **Square** | 125 | 107 | 0.002 | ns | 0.0006 |
| **Patterns** | 238 | 246 | 0.0001 | 0.0001 | 0.0001 |
| **Orientation(av.)** | 77 | 82 | 0.05 | 0.02 | 0.0008 |
| **Horizontal** | 77 | 82 | ns | 0.04 | 0.0006 |
| **Vertical** | 77 | 82 | ns | ns | 0.02 |
| **Oblique** | 77 | 82 | 0.03 | 0.01 | 0.002 |

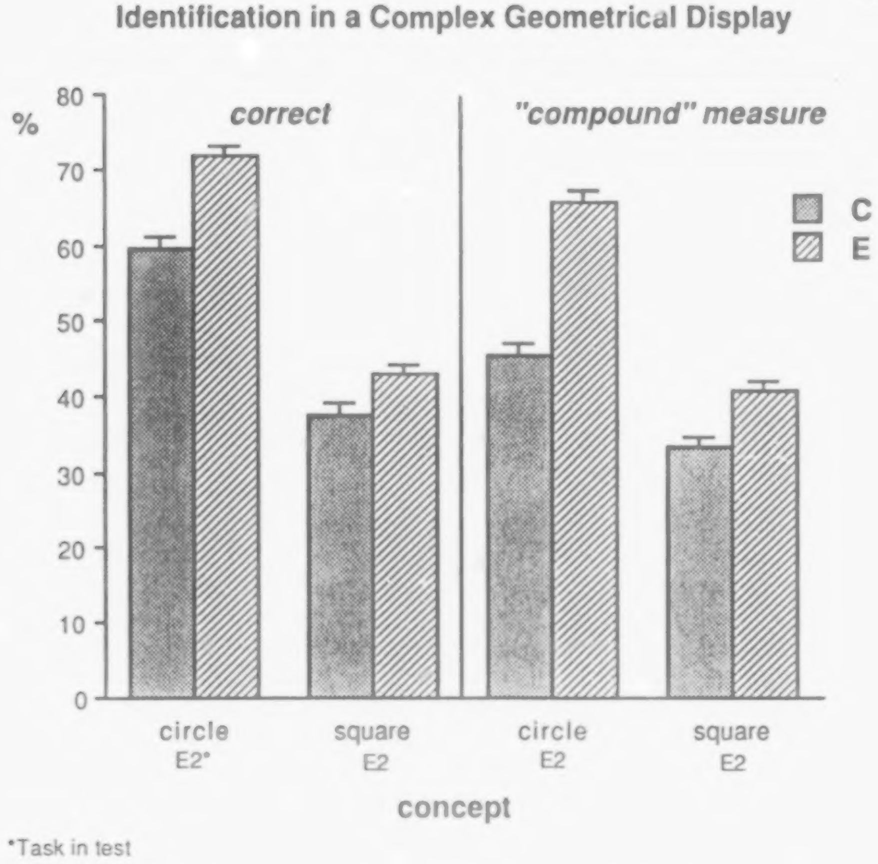
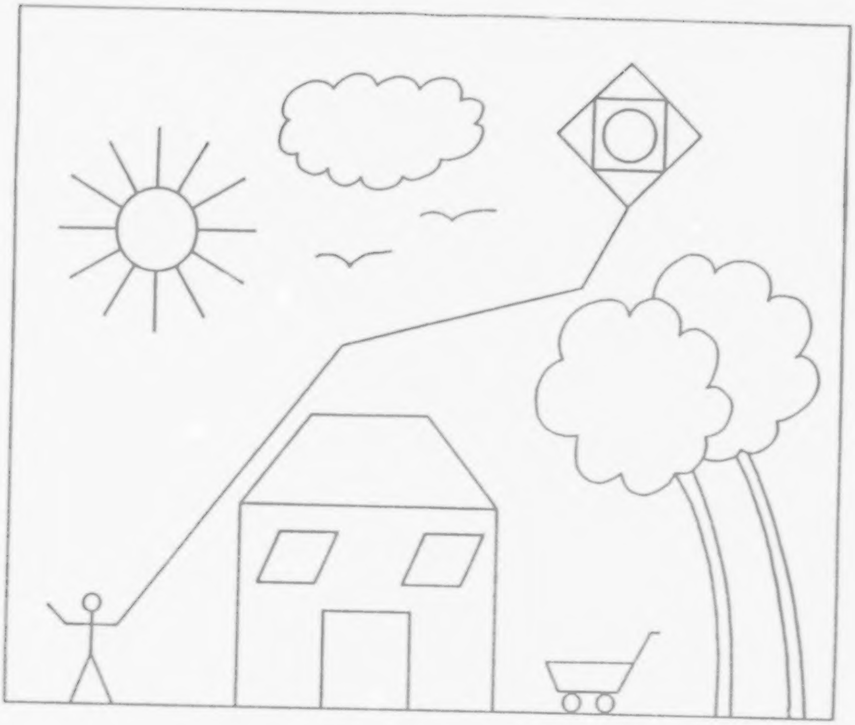


Figure 5.3: Corrected means adjusted for IQ and block. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle*** | 232 | 224 | 0.0001 | 0.0001 | 0.00005 |
| **Square** | 232 | 224 | 0.001 | 0.003 | 0.001 |
| | | | | | |
| **Circle**** | 232 | 224 | 0.0001 | 0.001 | 0.00005 |
| **Square** | 232 | 224 | 0.0002 | 0.01 | 0.00005 |

* Significance for % correct

**Significance for compound measure



C2

Figure 5.4
Identification of Orientations in a Realistic Picture
Children were asked to identify horizontal, vertical and oblique lines using three different colors.

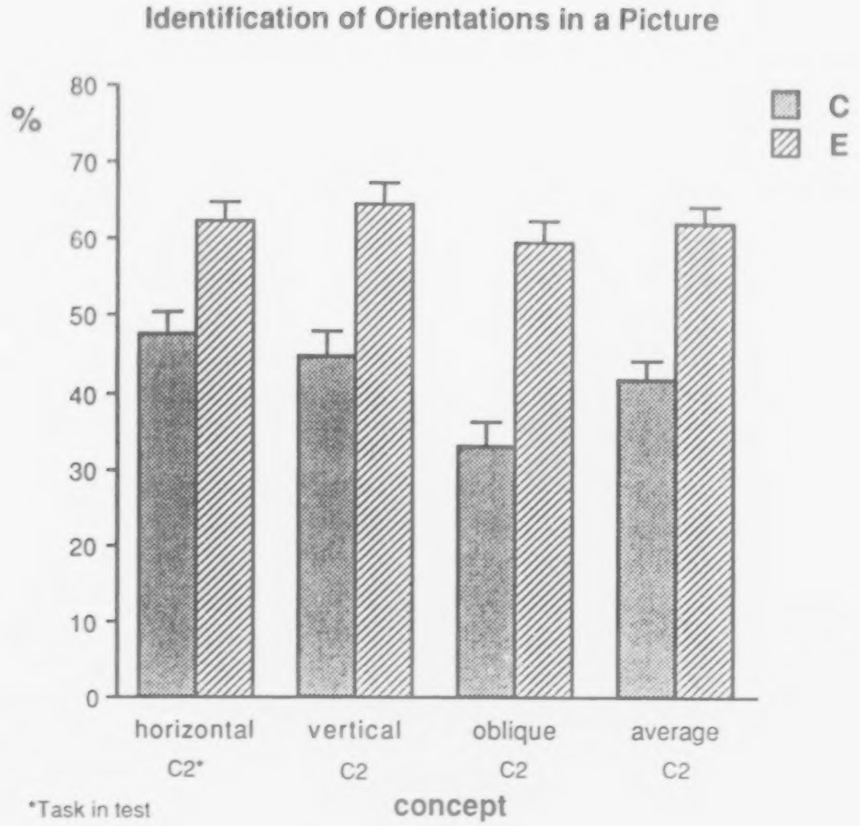


Figure 5.5a: Means of the percentage of correct answers adjusted for IQ and block. Error bars indicate standard error. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Horizontal*** | 77 | 82 | 0.0006 | 0.007 | 0.00005 |
| **Vertical** | 77 | 82 | 0.03 | 0.04 | 0.00005 |
| **Oblique** | 77 | 82 | 0.0009 | ns | 0.00005 |
| **Average*** | 77 | 82 | 0.0002 | 0.03 | 0.00005 |

*significant interaction between IQ and treatment (p<0.04)

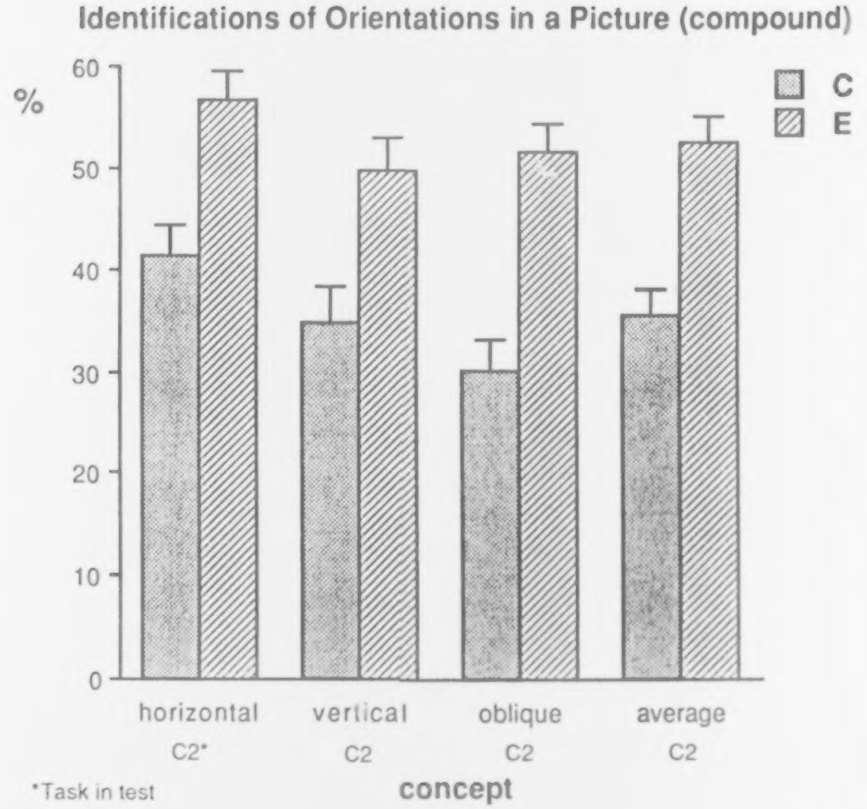


Figure 5.5b: Means of the compound measure adjusted for IQ and block. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Horizontal*** | 77 | 82 | 0.002 | 0.01 | 0.0001 |
| **Vertical** | 77 | 82 | 0.02 | ns | 0.001 |
| **Oblique** | 77 | 82 | 0.0003 | ns | 0.00005 |
| **Average** | 77 | 82 | 0.0005 | 0.02 | 0.03 |

*significant interaction between IQ and treatment (p<0.003)

Table 5.2: Mean percentages adjusted for IQ and block of correct answers for each object and each orientation in the picture of task C2. N(C)=77, N(E)=82.

| | Mean (C) | Stand. Error (C) | Mean (E) | Stand. Error (E) |
|---|---|---|---|---|
| **Wagon** | | | | |
| Horizontal | 47.3 | 3.9 | 63.6 | 3.7 |
| Vertical | 81.7 | 4.0 | 89.1 | 3.9 |
| Oblique | 33.7 | 4.9 | 62.1 | 4.7 |
| **House** | | | | |
| Horizontal* | 51.7 | 3.4 | 68.0 | 3.3 |
| Vertical | 51.6 | 4.2 | 70.9 | 4.1 |
| Oblique | 28.1 | 4.4 | 52.1 | 4.2 |
| **Child** | | | | |
| Horizontal | 67.1 | 5.3 | 72.3 | 5.1 |
| Vertical | 43.4 | 5.6 | 63.8 | 5.4 |
| Oblique | 32.2 | 4.7 | 63.8 | 4.5 |
| **String** | | | | |
| Horizontal | 77.9 | 4.2 | 91.8 | 4.1 |
| Vertical | 87.6 | 3.4 | 93.9 | 3.3 |
| Oblique | 53.8 | 4.4 | 76.7 | 4.3 |
| **Sun** | | | | |
| Horizontal | 31.2 | 5.2 | 32.8 | 5.0 |
| Vertical | 39.5 | 5.3 | 54.3 | 5.1 |
| Oblique | 24.7 | 5.1 | 48.1 | 4.9 |
| **Kite** | | | | |
| Horizontal | 41.6 | 5.3 | 64.3 | 5.1 |
| Vertical | 37.5 | 5.6 | 61.3 | 5.4 |
| Oblique | 40.8 | 4.9 | 75.0 | 4.7 |

*Significant interaction between IQ and treatment ($p<0.0002$)

experimental and comparison preschools. Thus, the results can be attributed only to the effect of the Agam Program. Four concepts were tested: circle, square, patterns and oblique. No time limit was set and the experimenter stopped only when the child could not find any more instances.

Two measures were obtained for each child: The total number of instances given by the child (Figure 5.6a) and the number of correct instances, i.e., examples of the concept (Figure 5.6b).

The results show that children in the experimental group correctly identified more instances of each concept than children in the comparison group. These results support the claim that the program "opens the children's eyes."

1.4 *Summary of identification*. In the above tasks, the skill of identification was examined by using stimuli that varied in the degree of visual complexity and context. For all concepts, the children in the experimental group performed significantly better than the children in the comparison group. Only in the simplest task of identifying a circle there was no difference between the groups. We shall discuss this finding in the section about the concept of "circle."

## 2. Memorization Tasks

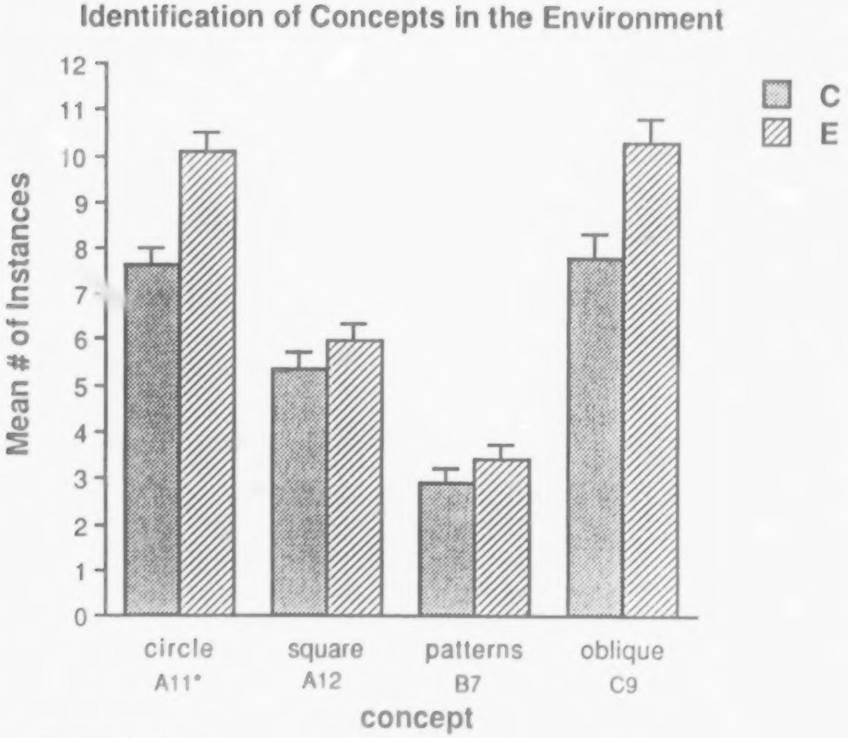
The tests included memorization tasks in various forms. In this section we report only about the simplest form: flash cards. Each child received a page with 9 displays of geometrical figures (see for example Figure 5.7). The experimenter showed one or two of these displays very briefly (for about 2 seconds). Each child had to mark the correct response. The results for the various concepts are reported in Figure 5.8

There were significant differences in favor of the experimental group, regarding the circle, the square, and patterns, but not for orientations.

## 3. Reproduction Tasks.

Throughout the tests there were many tasks that required reproduction of a stimulus. In this section we report only the most straightforward tasks of this type where children had to copy a stimulus with or without a grid of points or lines. We also report similar tasks in which children had to reproduce the stimuli from memory.

3.1 *Copy tasks*. In the simplest tasks of this category,

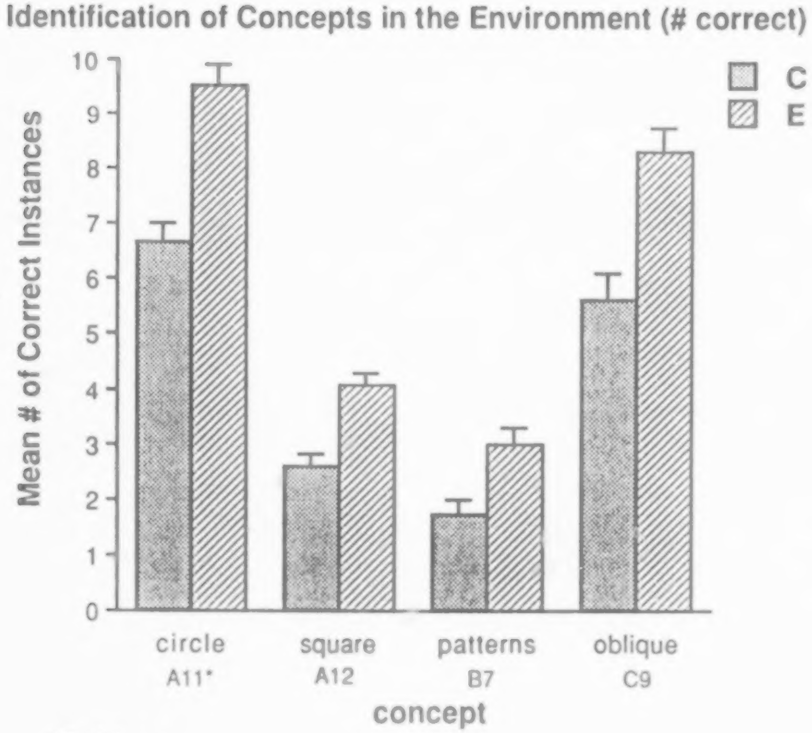


*Task in test

Figure 5.6a: Means adjusted for IQ and block of the number of instances identified for each concept . Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle*** | 125 | 107 | 0.001 | 0.0001 | 0.00005 |
| **Square** | 125 | 107 | 0.04 | 0.0001 | ns |
| **Patterns** | 110 | 106 | 0.004 | 0.0001 | ns |
| **Oblique** | 77 | 82 | 0.001 | ns | 0.0007 |

*significant interaction between IQ and block ($p<0.02$)

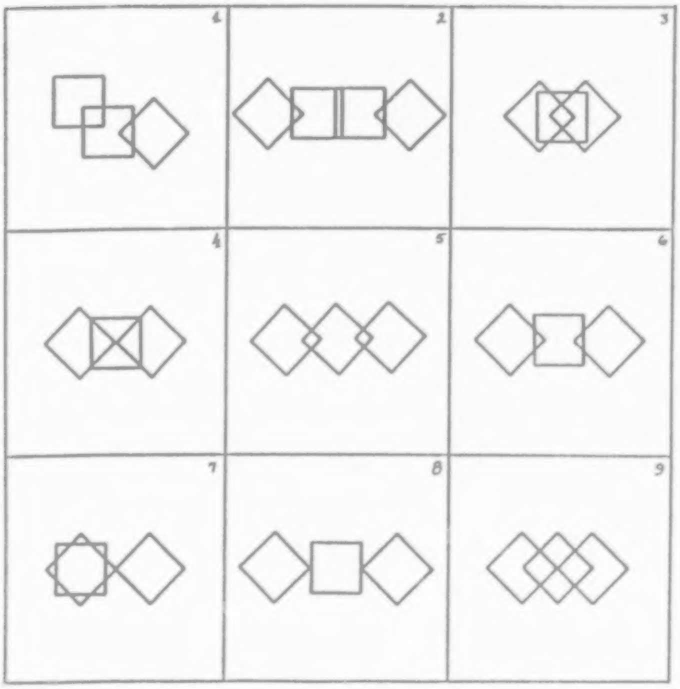

Identification of Concepts in the Environment (# correct)

*Task in test

Figure 5.6b: Means adjusted for IQ and block of the number of correct instances identified for each concept. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

| | | | P | | |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle*** | 125 | 107 | 0.005 | 0.0001 | 0.00005 |
| **Square** | 125 | 107 | ns | 0.0001 | 0.0005 |
| **Patterns** | 110 | 106 | 0.04 | 0.0001 | 0.001 |
| **Oblique** | 77 | 82 | 0.0001 | 0.0001 | 0.0005 |

*significant interaction between IQ and block ($p<0.03$)



A9

Figure 5.7
Example of Flashcard Memory Task
A sample page with displays of geometrical figures used in a flashcard memory task.

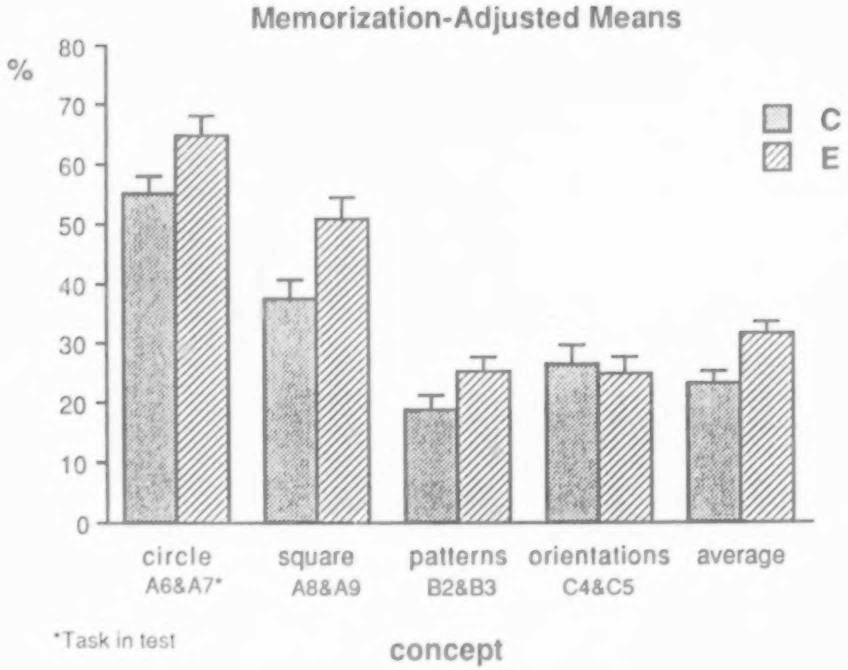


Figure 5.8: Mean percentages of correct answers adjusted for IQ and block. Error bars indicate standard errors. The table below gives the figures for statistical significance from the ANCOVA.

|  |  |  | P |  |  |
|---|---|---|---|---|---|
| Concept | N(C) | N(E) | IQ | Block | Treatment |
| **Circle** | 125 | 107 | 0.0001 | 0.01 | 0.02 |
| **Square** | 125 | 107 | 0.001 | ns | 0.002 |
| **Patterns** | 220 | 235 | ns | ns | 0.04 |
| **Orientations** | 77 | 82 | ns | ns | ns |
| **Average** | 283 | 289 | 0.002 | 0.0001 | 0.002 |

children were asked to copy a display of geometrical forms. Three of the tasks come from the circle/square test and one task comes from the test given at the end of the year (see Figure 5.9).

One of the circles in A3-a and one of the squares in A4 (those denoted by x) were chosen for evaluating the quality of the drawing. The procedure for judging the quality of the drawing was adapted from the WPPSI test. In addition, a categorization scheme was developed to examine student performance on several other aspects: the number of forms (e.g. the number of circles in A3-a), the spatial relationships between the forms, and their sizes. Table 5.4 details the adjusted means for each copy task in terms of the quality of the drawing (when relevant) and subscores of the above-mentioned aspects.

(a) Drawing quality of a single circle and a single square. Table 5.3 presents the adjusted means for the drawings of the circle and the square. Each group, irrespective of training, had higher scores for the drawing of the circle than for the drawing of the square. For both forms, there was a significant difference between the scores of the two treatment groups. This is not surprising in light of the directed experience that children received in the Agam Program.

(b) Other subscores. The scores shown in Table 5.4 were obtained by converting each of the subscores to percentages and by giving equal weights to each of the subscores. This procedure was possible because of the hierarchical nature of the categorization scheme.

Differences between the groups were found only in two of the tasks; however, these tasks were the most complex tasks given. These differences were most pronounced in the measure of relative position.

3.2 Copy on grid. Figure 5.10 gives examples of these tasks. Both types were difficult for all the children. About a quarter of the children did not attempt to do them, and among the rest, the rate of success on most of the submeasures was between 20 and 50 percent. There was a strong effect of intelligence and block ( $p< 0.0001$) and no effect of treatment in most submeasures. Informal observations revealed that children used a variety of strategies to do these tasks. The most common was an "analytic approach" where children attempted to reproduce the stimuli line by line without any reference to more global forms (i.e., a square). Most of these children did not use a systematic strategy and thus forgot some of the lines. Another strategy entailed a "global approach". Children attempted to reproduce the global forms and subforms. To these children, the grids were a nuisance

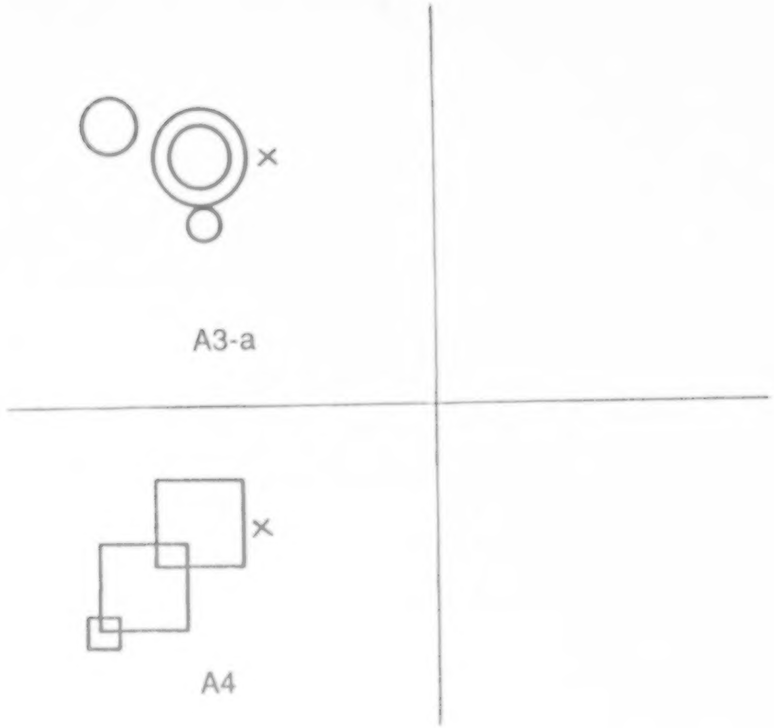


Figure 5.9
Copy Tasks
See text for discussion.

Table 5.3: Drawing quality of a single circle and a single square in tasks A3-a and A4. Means are adjusted for IQ and block. Scoring scheme adapted from WPPSI.

| Corrected means (S.E.) | C (N=125) | E (N=107) | P IQ | P Block | P Treatment |
|---|---|---|---|---|---|
| **Circle** | 63.2<br>(2.9) | 71.3<br>(3.2) | ns | ns | 0.03 |
| **Square** | 40.4<br>(3.2) | 53.2<br>(3.5) | 0.03 | ns | 0.004 |
| **Average** | 51.8<br>(2.3) | 62.3<br>(2.5) | 0.03 | 0.04 | 0.001 |

Table 5.4: Means adjusted for IQ and block for the total scores of the copy tasks. Some of the tasks are shown in figure 5.9.

| | | | P | | |
|---|---|---|---|---|---|
| Copy Tasks | C<br>(N=125) | E<br>(N=107) | IQ | Block | Treatment |
| A3-a (average) | 65.5 (1.6)** | 70.5 (1.8) | 0.0002 | ns | 0.02 |
| Quality | 63.2 (2.9) | 71.3 (3.2) | ns | ns | 0.03 |
| Number* | 85.7 (1.9) | 87.9 (2.1) | 0.002 | ns | ns |
| Relative pos. | 61.8 (2.2) | 71.4 (2.4) | 0.0002 | ns | 0.002 |
| Size | 51.2 (2.3) | 51.4 (2.5) | 0.0009 | ns | ns |
| A3-b (average) | 75.3 (1.8) | 72.5 (2.0) | 0.0001 | ns | ns |
| Number | 91.8 (2.1) | 89.1 (2.3) | 0.0001 | ns | ns |
| Relative pos. | 72.6 (2.2) | 68.5 (2.4) | 0.0008 | ns | ns |
| Size | 61.5 (2.4) | 59.9 (2.7) | 0.0001 | ns | ns |
| A4 (average) | 63.2 (1.9) | 62.7 (2.0) | 0.0001 | ns | ns |
| Quality | 40.4 (3.2) | 53.2 (3.5) | 0.03 | ns | 0.004 |
| Number | 87.7 (2.3) | 84.2 (2.5) | 0.0001 | ns | ns |
| Relative pos. | 62.6 (2.6) | 62.7 (2.9) | 0.0001 | ns | ns |
| Size | 62.2 (2.0) | 50.6 (2.2) | 0.0001 | ns | 0.00005 |
| E1 (average) * | 61.6 (1.5) | 67.7 (1.5) | 0.0001 | 0.002 | 0.002 |
| Quality* | 62.6 (1.6) | 68.6 (1.7) | 0.0001 | 0.0006 | 0.005 |
| Number* | 80.8 (1.8) | 86.3 (1.8) | 0.0001 | 0.02 | 0.01 |
| Relative pos. | 41.9 (1.6) | 52.0 (1.6) | 0.0001 | 0.009 | 0.00005 |
| Size* | 61.0 (1.7) | 63.8 (1.7) | 0.0001 | 0.001 | ns |
| E4-a (average) | 39.9(2.1) | 41.2(2.2) | 0.0001 | 0.0001 | ns |
| Quality | 46.4(2.4) | 47.3(2.4) | 0.0001 | 0.0001 | ns |
| Number | 52.3(2.6) | 52.2(2.6) | 0.0001 | 0.0001 | ns |
| Relative pos. | 26.5(2.0) | 26.3(2.1) | 0.0001 | 0.0007 | ns |
| Size | 34.3(2.3) | 39.2(2.3) | 0.0001 | 0.0001 | ns |
| E4-b (average) | 22.5(2.1) | 26.1(2.1) | 0.0001 | 0.0001 | ns |
| Quality | 23.1(2.1) | 25.9(2.1) | 0.0001 | 0.0001 | ns |
| Number | 37.5(2.7) | 36.4(2.7) | 0.0001 | 0.0001 | ns |
| Relative pos. | 21.1(2.5) | 26.2(2.6) | 0.0001 | 0.001 | ns |
| Size | 8.5(1.9) | 15.9(1.9) | 0.0001 | ns | 0.003 |

*significant interaction between IQ and treatment ($p<0.01$)
**standard error

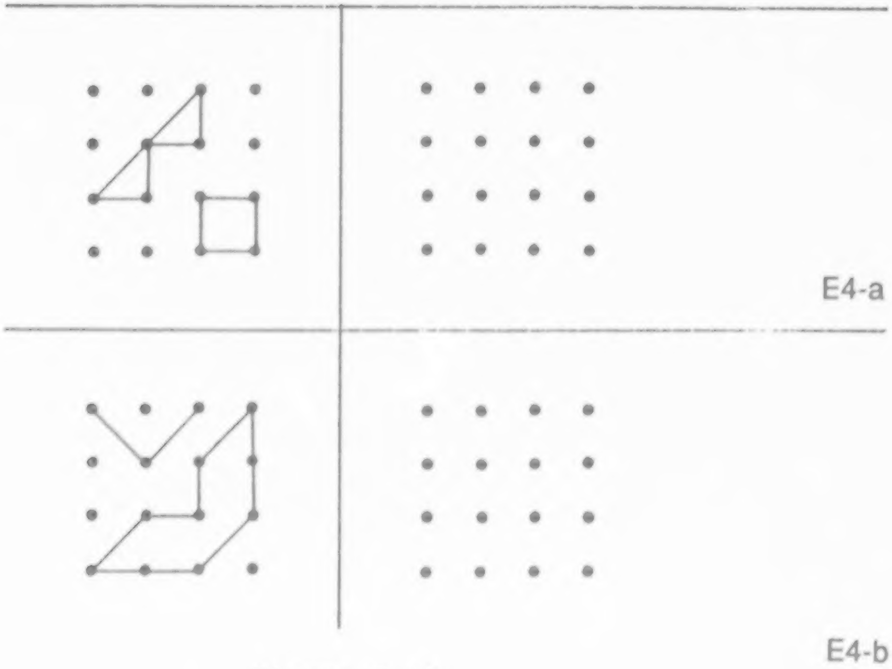


Figure 5.10
Copy on Grid Tasks

rather than help and they had great difficulty in placing the forms on the grid. Many of these children also lacked a systematic approach to the task.

3.3 Reproduction from memory. There were two reproduction from memory tasks at the basic level. In one, children were briefly shown a display with a combination of circles and were asked to reproduce it from memory. In the other task, they had to reproduce from memory a pattern. Both stimuli are shown in Figure 5.11.

Table 5.5 presents several parameters describing the drawings of the children in A10. A significant difference was found between the groups in the measure of relative position. In the B4 task, there was a significant difference between the groups ($p < 0.05$) only in the correctness of the pattern. This task was difficult for all children; about two-thirds of each group drew the pattern incorrectly. The distribution of incorrect patterns was quite similar in both groups.

3.4 Summary of reproduction. Effect of the treatment was found in the quality of drawing a circle and a square and in the copying of more complex forms. It is interesting to note that students in the Agam Program performed better in the aspect of relative position both in the reproduction from memory and the copying tasks (see Table 5.4).

No differences were found between the treatments in copying on a grid; these tasks were difficult for all children. Children used both "analytic" and "global" approaches in drawing, and their errors were mainly due to the lack of a systematic approach in copying. In reproduction from memory tasks, significant differences were found in both tasks.

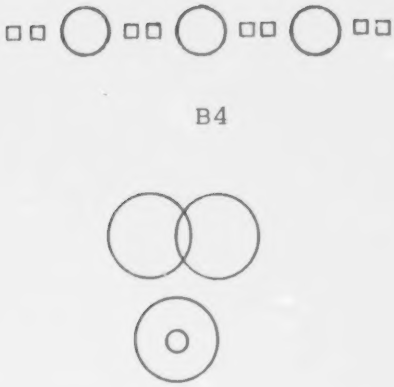
## C. BASIC VISUAL CONCEPTS

The following section examines the results with a focus on the relevant concepts.

### 1. Circles and Squares

Children's understanding of the concepts of circle and square were examined in three different identification tasks (see Figures 5.2, 5.3, and 5.6). In this section we discuss in greater detail the meaning of these results.

The results show that most children, both in the experimental and comparison groups, correctly identified instances of circles and squares in the simple geometric context. There was no significant difference for circle,



B4

A10

Figure 5.11
Reproduction From Memory Tasks
Children were briefly shown a display and asked to draw it from memory (B4 and A10).

Table 5.5: Means adjusted for IQ and block of some parameter characterizing children's reproduction from memory in task A10.

| | | | P | | |
|---|---|---|---|---|---|
| Parameters | C<br>(N=125) | E<br>(N=107) | IQ | Block | Treatment |
| **Number of forms** | 73.5<br>(2.3)* | 73.2<br>(2.5) | ns | 0.0001 | ns |
| **Relative position** | 42.6<br>(2.7) | 49.1<br>(3.0) | 0.02 | 0.0005 | 0.05 |
| **Size** | 45.4<br>(3.8) | 53.2<br>(4.2) | 0.02 | ns | ns |

*standard error

but the difference was significant for squares. The most prevalent confusions were the following: identifying ellipses as circles (1.9% in E vs. 8.8% in C) and identifying rotated squares as non-squares (average of 3.7% in E vs. 11.2% in C).

The results were quite different in the more complex contexts. In the complex geometric context, the percentage of correct identifications dropped considerably in both groups, but more so in the comparison group, resulting in a significant difference in favor of the experimental group. The means for each of the forms are given in Figure 5.12.

A close examination of the figures suggests two possible explanations for this drop. The comparison group had (1) a weaker understanding of the concepts and (2) difficulty in visual analysis. In other words: (1) The increased visual complexity amplified the difficulties that were also observed in the simple context, (e.g., identification of an ellipse as a circle, a rectangle as a square and a rotated-square as a non-square). (2) The increased visual complexity also complicated visual analysis. Thus, the circle on the left, which hardly intersects any other form, and is in its prototypical position, was identified by 98.2% in E and 93.5% in C; however, the intermediate circle in the upper right side of the figure was identified only by 29.5% of E and 20.7% of C.

Considerable differences were also found where the children had to find examples of circles and squares in their class environment (see Figure 5.6).

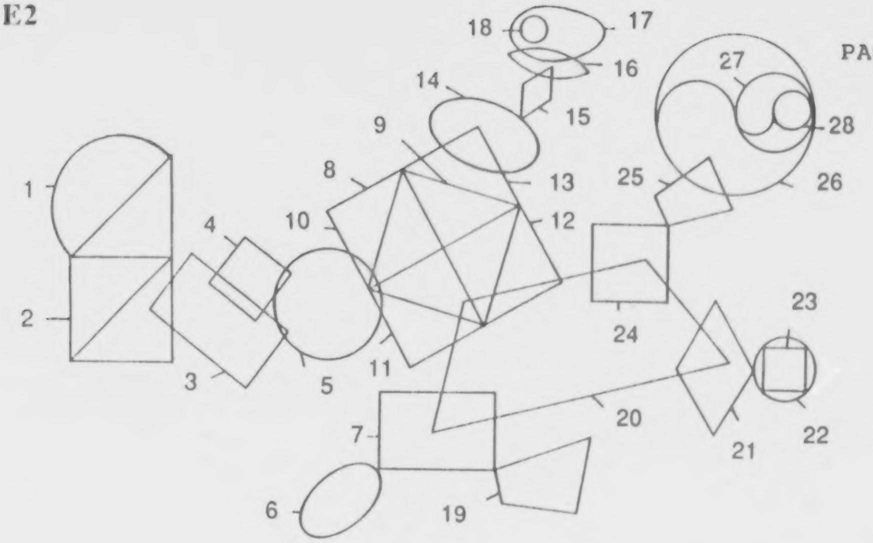
1.1 Summary of circle and square. The concept of circle, and to a lesser degree the concept of square, were quite familiar to all children in the simple geometric context. The most prevalent confusion had to do with ellipses, in the case of circles, and rotated squares, in the case of squares.

Yet, as the visual context became more complex, the performance was reduced considerably for all children and significant differences were found between the experimental and comparison groups. These results suggest that children trained in the Agam Program acquired a more robust understanding of the concepts and the visual training enabled them to better apply their knowledge in a more complex visual context.

## 2. Patterns

In the Agam Program, we define a pattern as a series of geometric forms that repeats itself. The concept of

**Task E2**



| Form number | Circle (red) C (N=224) | Circle (red) E (N=232) | Square (blue) C (N=224) | Square (blue) E (N=232) |
|---|---|---|---|---|
| 1 | 8.6 | 3.1 | 1.7 | 0.09 |
| 2 | 0.9 | 0.9 | 60.8 | 69.2 |
| 3 | 0.9 | 0.5 | 13.8 | 4.5 |
| 4 | 0.9 | 0.5 | 78.0 | 80.8 |
| 5 | 93.5 | 98.2 | 1.7 | 0.0 |
| 6 | 51.7 | 21.9 | 1.7 | 0.0 |
| 7. | 0.4 | 0.0 | 19.8 | 4.9 |
| 8 | 1.3 | 1.8 | 72.0 | 80.4 |
| 9 | 0.4 | 0.5 | 23.3 | 42.4 |
| 10 | 0.4 | 0.5 | 9.1 | 8.5 |
| 11 | 0.0 | 0.5 | 8.6 | 7.6 |
| 12 | 0.0 | 0.5 | 9.1 | 8.0 |
| 13 | 0.0 | 0.9 | 8.6 | 7.6 |
| 14 | 45.3 | 17.0 | 1.3 | 0.0 |
| 15 | 0.9 | 0.5 | 5.2 | 9.4 |
| 16 | 4.7 | 0.9 | 0.0 | 0.0 |
| 17 | 29.3 | 9.4 | 0.0 | 0.0 |
| 18 | 42.7 | 58.5 | 0.0 | 0.0 |
| 19 | 0.4 | 0.0 | 4.7 | 0.9 |
| 20 | 0.0 | 0.0 | 2.2 | 0.5 |
| 21 | 1.3 | 0.0 | 9.9 | 9.8 |
| 22 | 78.9 | 88.8 | 1.3 | 1.3 |
| 23 | 3.0 | 1.8 | 15.5 | 31.7 |
| 24 | 0.4 | 0.0 | 88.8 | 87.1 |
| 25 | 1.7 | 0.0 | 7.3 | 0.5 |
| 26 | 81.0 | 87.5 | 0.4 | 0.9 |
| 27 | 20.7 | 29.5 | 0.4 | 0.0 |
| 28 | 43.1 | 62.1 | 0.4 | 0.5 |

Figure 5.12

In task E2 children were asked to trace the circles in red and the squares in blue. The table shows for each form the percentages of children in the two groups who marked the form as circle or as square.

pattern, in general, and a geometrical pattern, in particular, plays an important role both in young and adult reasoning. Children's drawing and singing suggest that they acquire this concept at a very young age. However, informal observations indicate that this acquisition is limited to very simple patterns and that children do not differentiate between a repetitive series of geometrical forms and a "nice" series, e.g., one which has some symmetry features. The various tasks in the test attempted to test the degree to which children in the Agam Program acquired a more sophisticated understanding of the concept and a better ability to apply it.

The "patterns" test (see Appendix 2) included several tasks that examined these aspects: A production task (draw a pattern), a debugging task (recognize examples and non-examples), and a completion task (continue the pattern). Three additional tasks were already reported and will only be mentioned: a memory task, a reproduction from memory task and a task to find examples of the concept in the class environment. Before administering the test, the concept was explained to all children in simple terms and illustrated by a necklace of alternating circles and squares.

Table 5.6 presents the adjusted mean scores for each of the tasks and the significance levels for IQ, block and treatment. In the next paragraphs we discuss in turn each of the tasks.

2.1 Production task. In task B1, children were asked to draw any pattern that they chose. Most of the children did the task. As Table 5.6 shows, there was a significant difference in B1 between the groups ($p<0.0008$). A more in-depth analysis of this task shows that the differences were significant in many aspects (i.e., dimensions, element complexity, spacing and number of elements), although not size (see Table 5.7).

2.2 Debugging task. In their booklets, the children were given three series two of which were patterns and one which was not. They were asked to identify which were not patterns and to indicate where "it should be corrected". About 80% of the children did the task in both groups. However, there was a considerable difference: 69.5% in the experimental group could recognize the correct patterns ,vs. 55.9% in the comparison group; 58.5% in the experimental group could recognize the incorrect patterns and indicate the error, vs. 35.3% in the comparison group. There were additional 14.6% of the children in E that recognized the incorrect pattern but could not point to the error vs. 28.6% in C.

Table 5.6: Means adjusted for IQ and block of the summary scores for each of the tasks in the patterns test.

| Tasks | C (N=110) | E (N=106) | P | | |
|---|---|---|---|---|---|
| | | | IQ | Block | Treatment |
| Produce a Pattern (B1) | 33.6<br>(1.9)* | 42.4<br>(2.0) | 0.0001 | ns | 0.0008 |
| Memorize** (B2-B3) | 18.8<br>(2.6) | 25.6<br>(2.5) | ns | ns | 0.04 |
| Reproduce from memory (B4) | 18.5<br>(3.5) | 24.4<br>(3.6) | 0.0001 | 0.04 | 0.05 |
| Debug** (B5) | 62.9<br>(1.8) | 78.1<br>(1.8) | 0.0001 | 0.0001 | 0.00005 |
| Complete (B6) | 47.6<br>(1.9) | 56.5<br>(2.0) | 0.0001 | ns | 0.0006 |
| Identify in Environment(#cor) (B7) | 1.7<br>(0.3) | 3.0<br>(0.3) | 0.04 | 0.0001 | 0.001 |

*standard error

**N(C)=238; N(E)=246. These different sample sizes are due to the fact that the "patterns short test" included only items B2 and B5.

Table 5.7: Means adjusted for IQ and block for some of the properties of the patterns produced by children in task B1. Patterns were scored on a hierarchical categorization scheme, and the scores were given on a scale of 100 proportionally to the placement on the scale. The categories are explained below.

| | | | P | | |
|---|---|---|---|---|---|
| **Properties** | **C**<br>(N=109) | **E**<br>(N=101) | **IQ** | **Block** | **Treatment** |
| **Dimensions** | 50.4<br>(3.1)* | 63.3<br>(3.4) | 0.0001 | ns | 0.003 |
| **Element complexity** | 46.9<br>(2.8) | 60.9<br>(3.0) | 0.0001 | ns | 0.0005 |
| **Spacing**** | 17.5<br>(2.0) | 26.5<br>(2.1) | 0.009 | ns | 0.001 |
| **Size** | 28.5<br>(2.6) | 33.8<br>(2.7) | 0.005 | 0.007 | ns |
| **Number of elements** | 35.9<br>(2.0) | 40.1<br>(2.2) | 0.0004 | ns | 0.002 |

*standard error

**significant interaction between IQ and block ($p<0.05$)

Categories:

**Dimensions**: Scale for judging the accuracy in manipulating the various dimensions defining the pattern such as the various shapes, their sizes etc.

**Element complexity**: The number of individual or compound shapes in each cycle of the pattern.

**Spacing**: Scale for judging accuracy of manipulating the spacing between elements in a cycle and between cycles.

**Size**: Scale for judging accuracy of size and relative size.

**Number of elements**: Numbe of elements per cycle relative to the maximal number of elements in the sample.

2.3 Completion task. The children were given several cycles of three different patterns and were asked to continue each of them. Overall, there were considerable differences ($p<0.0006$) between the groups. Again, children in the comparison group had difficulty in keeping track of all the variables and captured only some of the features of the patterns.

2.4 Memory, reproduction and identification tasks. Results on these tasks were described in the previous section (Figures 5.6, 5.8 and 5.11). Differences were found in the memory, reproduction and identification tasks indicating a robust understanding of the concept and ability to apply it in a complex visual context.

2.5 Summary of patterns. The results of the various tasks in the patterns test suggest that all children possess some knowledge of the concept of "patterns" irrespective of training. This knowledge, however, is restricted to very simple patterns and the concepts of pattern and a "nice" series (e.g. one with some symmetry) are not well-differentiated. As a result of the Agam Program, children extended their understanding of the concept to more complex instances and they could better keep track of the various variables that were manipulated. In general, it seems that for some of the children, understanding the concept has been elevated from the intuitive level to the more abstract logical level- an important step towards more general reasoning with patterns.

## 3. Orientations

As reported in the previous section, acquisition of the three orientation concepts (horizontal, vertical and oblique lines) were tested in a variety of identificaiton tasks presented in different contexts: (1) In a simple geometric context where the stimuli were isolated lines in different orientations along with a few curved lines; (2) In a realistic picture (see Figure 5.4); and (3) In the preschool class itself.

In all of these tasks, there was a significant advantage to the Agam-trained children. The difference was most pronounced in the oblique concept (see Figure 5.5 and Table 5.2 for the results). Children in the experimental group had about the same level of performance for the three orientations. This was not the case for the comparison group in which children had considerably more difficulty in identifying oblique orientations than identifying the horizontal or vertical orientations. Some confusion between oblique and curved lines was found in both groups, although it was more frequent in the comparison group. In the simple geometric context, only about 15% of the children chose the curved lines to represent an oblique; however, this was not the case for the realistic picture, where about 30% of the children (in each of the groups) marked curved lines, (e.g., like the trunk of the tree) as obliques. Although better distinction between oblique and curved lines is probably acquired later in the program, when children learn about the curved line, the current situation is not desirable. The inclusion in the Agam Program of curved lines as nonexamples to the oblique line (in addition to the horizontal and vertical nonexamples) can be useful in remediating this problem.

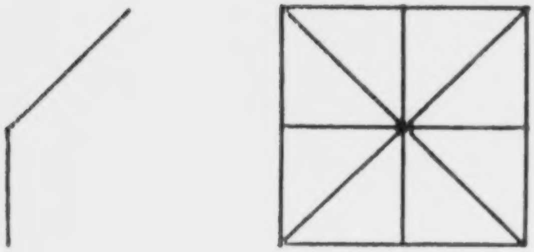
Three additional tasks involved manipulation of lines. Figure 5.13 shows examples of these tasks. In one task, children had to find a combination of lines in a figure which had additional lines (hidden figure tasks). In another task, children had to choose from among a set of line segments those that would complete a partial form to a desired one (completion task). The third task was a visual dictation task where children had to draw in their booklets a sequence of orientations shown by the experimenter.

(1) Hidden figure task. There was no difference between the groups in this task. Children's performance was judged on a variety of descriptors. Overall performance was rather poor. In both groups, only 30-40% correctly marked the various figures; the main factor that affected performance was IQ ($p<0.00001$ for the summary score of the various tasks).

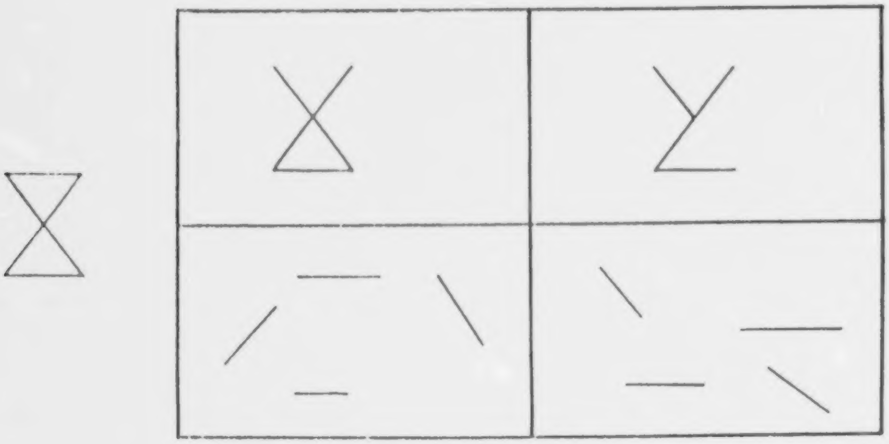
(2) Completion tasks. These tasks consisted of pairs like those shown in Figure 5.13. As expected, the second task in each part was more difficult than the first. Table 5.8 shows the corrected means for each of the tasks. There were no significant differences between the groups.

(3) Dictation Task. Children's performance was judged both on the correctness of the whole pattern and for each line separately. On the average, children in the Agam Program performed better than children in the comparison group ($p<0.02$). Out of the nine lines in the dictation, children in the experimental group reproduced about six lines correctly vs. five lines in the comparison group.

In the section on transfer we report about another set of three items that were given in the "orientation" test. Children were given a form of an open triangle that represents the slopes of a mountain and were given three different opportunities to draw a tree on one of the slopes. First, they were asked to draw without any help, then they were shown the correct drawing and were asked to copy it; finally, they were again given the bare slopes and asked to draw the tree without any help. The results indicate that in the copying task, children in the



C3-b



C6C-a C6C-b

Figure 5.13
Examples of Orientation Tasks
Tasks included: identifying a hidden figure (C3-b), and finding the line or lines needed to complete a figure (C6C-a and C6C-b).

Table 5.8: Means adjusted for IQ and block for the completion items in task C6. An example of a pair of items is shown in figure 5.13.

| | | | P | | |
|---|---|---|---|---|---|
| | C | E | IQ | Block | Treatment |
| | (N=77) | (N=82) | | | |
| **C6A-a** | 75.5<br>(4.8)* | 81.8<br>(4.6) | ns | ns | ns |
| **C6A-b** | 67.9<br>(4.0) | 74.0<br>(3.9) | ns | 0.01 | ns |
| **C6B-a** | 73.7<br>(4.8) | 68.2<br>(4.6) | 0.0006 | 0.0001 | ns |
| **C6B-b** | 53.4<br>(3.7) | 50.1<br>(3.6) | 0.002 | 0.05 | ns |
| **C6C-a**** | 44.8<br>(5.7) | 45.0<br>(5.5) | ns | ns | ns |
| **C6B-b** | 45.5<br>(3.7) | 36.6<br>(3.6) | 0.0001 | 0.01 | ns |

*standard error

*significant interaction between IQ and block (p<0.002) experimental group performed better than the other children ($p<0.03$) and were able to draw the tree more towards the upright position; the general tendency of children is to draw the tree perpendicular to the slope. In the next drawing without help, there were considerable gains for the experimental but not for the comparison group.

3.1 Summary of orientations. Agam-trained children could better identify the horizontal, vertical and oblique orientations in a variety of contexts. The differences were most pronounced in the oblique concept. Confusion of oblique with the curved line was found both in the experimental and comparison groups. This suggests the need for adding curved lines as non-examples in the Oblique Unit. The advantage of the trained children in the drawing of a "tree on a mountain" suggests that within the context of orientations, children had better observational skills and could better respond to a stimulus that contradicted their internal image. Furthermore, more gains were found. There were several tasks, such as hidden figures and completion tasks, where no differences were found: only marginal differences were found in the dictation task.

## VI. RESULTS: TRANSFER

The previous sections examined the effects of the Agam Program on the acquisition of visual concepts and processes directly trained by the program. In the present section we describe transfer of the program's effects to various cognitive domains not directly trained by the program. We discuss the following domains: complex visual processes (fine motor skills, complex identification, memorization and reproduction), visual learning, mathematical readiness, intelligence, and creativity.

### A. COMPLEX VISUAL PROCESSES

#### 1. Fine Motor Skills

It was expected that children who participated in the Agam Program would improve their fine motor skills more than children in the comparison group. These skills are essential for a great variety of tasks, such as writing tasks. Three tasks investigated these skills in the final test (see Figure 6.1). In tasks F1 and F2 the children were asked to draw a square and a star between the corresponding two shapes and in F3 they were asked to copy the stimulus.

In tasks F1 and F2 the number of children who drew the figures in the desired place ,between the two shapes, was significantly larger in the experimental group than in the comparison group ($p<0.006$). In F1 the percentages were 72.9% in C vs. 90.8% in E, and in F2 the percentages were 70.5% in C vs. 85.2% in E. There were no significant differences between the groups in other aspects of the drawings.

In the copying task, F3, performance in both groups was very good. There was no significant difference between the two groups, neither in most of the global aspects of reproduction (e.g., the ordering of the stimuli, etc.) nor in the more detailed aspects of the reproduction (e.g., whether some lines are straight as in the stimuli, etc.).

#### 2. Complex Identification

Several tasks probed children's ability to identify some stimuli (or missing stimuli) in a complex visual display. The most important skills in these tasks is one of visual discrimination. The tasks varied in the type of the stimuli as well as in the activity that the children had to do. We can categorize the tasks into two types: (1)

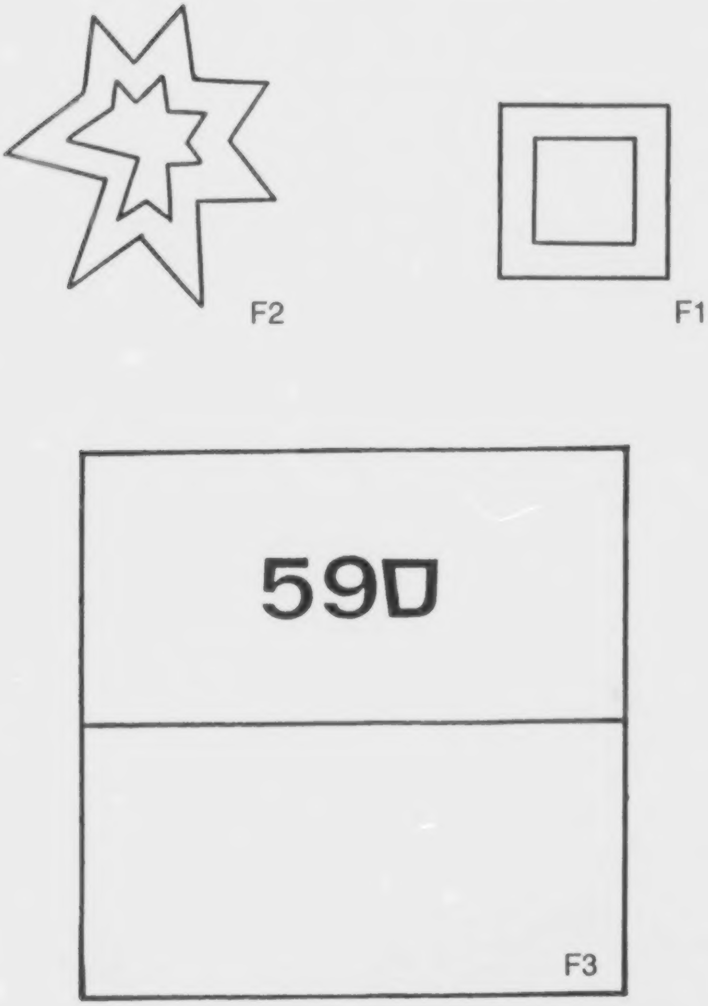


Figure 6.1
Fine Motor Skills
Instructions were as follows. For F1: "Draw an inner square between the small square and the large square." For F2:"Draw an inner star between the small star and the big star." For F3: "Copy in the space below."

Hidden figure tasks, (2) "Identify the difference" tasks.

2.1 Hidden figure tasks. Three hidden figure tasks were given at the end of the second year. In one task (F11) children had to find a diamond shape in a geometrical display of lines. In another task (F12) children had to find a fish hidden in a complex picture. In the third task (D1), children had to find various geometrical shapes hidden within the same geometrical display. There were no significant differences between the groups in these three tasks. A related task of somewhat different nature (D4) was adapted from Salomon (1974). In this task the children were shown an enlarged piece of a picture and had to identify which of four different pictures included this piece. In the complete picture, the size of the piece was much smaller, thus requiring the children to zoom in. There was no difference between the groups in the performance of this task.

Another hidden figure task, F7, was somewhat different than the others. In this task, students were asked to identify complex geometrical shapes partly hidden by a square. In the 4 tasks, we found a significant difference in favor of the experimental group ($p<0.04$).

2.2 "Identify the differences" task. In F10 children had to identify certain strings of words or numbers from several distractors. There were no significant differences between the groups.

## 3. Complex Memorization

Three memorization tasks were given, one at the end of the first year (E6) and two at the end of the second year (D5, D6). All tasks involved pictures. In E6 and D6, the experimenter showed briefly a picture. The children had in their test booklets pictures of different objects and had to mark (from memory) those that appeared in the picture shown previously. In D5 the picture had a network of roads. The children had the same picture in their test booklets. The experimenter showed a continuous path "traveled by a dog" through some of the streets. The children had to trace from memory the path in their booklets.

In E6, nine alternative answers were given; three were correct (i.e., they had the same form as objects in the picture) three had the same names as objects in the picture, but not the same forms (e.g., a different kind of tree) and three had similar, but not identical, forms as objects in the picture. Table 6.1 shows the adjusted means for the three types of distractors. As can be seen, the only significant difference between the groups was in the verbally similar distractor; here the comparison group had a lower rate of error (p<0.02). Thus, children in the comparison group could better recognize stimuli with similar names but different form as not appearing in the picture. No significant differences were found in the percent of correct answers and in the visually similar distractors. No significant differences were found in the other two memorization tasks.

## 4. Complex Reproduction and Reproduction from Memory

Two complex reproduction tasks were given at the end of the second year. In one task (E3, see Figure 6.2) the children had to complete the missing items in each of the shirts.

Children's drawings were analyzed with regard to four aspects: the forms drawn , the orientation of the forms, their relative sizes and their position. In all variables there was a strong dependence of performance on intelligence and block (p<0.0001). In two of the variables (form and orientation) there was a significant advantage for the Agam-trained group (p<0.0006).

A second set of tasks, F4 and F5, involved two consecutive drawings of Rey's composition (see Figure 6.3). Children had to copy the composition and in the second task had to reproduce it from memory.

The performance of the children was rated on a great number of variables. First the reproduction was examined globally to see whether children attempted to synthesize the individual elements in the drawing rather than draw individual elements. There was a signifcant advantage (p<0.0007) of the Agam-trained children. A significant difference was also found on this aspect in F5 (p<0.006). At a more detailed level, the drawings were examined with respect to questions such as: Does each element appear in the reproduction? Does it have the correct geometrical properties? Is the intersection of elements accurate? For each of the categories a mean score was computed. Children in the Agam group reproduced significantly more elements than children in the comparison group (p<0.01), and reproduced more accurate details (p<0.009). There was also a significant difference in the relative position of the elements (p<0.04). But there was no significant difference in the geometrical accuracy in the drawings of elements and their intersections. In a previous study, Razel & Eylon (1990) found significant differences between the groups for both tasks, and the difference between the groups was higher in the second than in the first task, indicating

Table 6.1: Adjusted means for three types of alternative answers in memorization task E6. The means are adjusted for IQ and block. The scores ranges from 0 to 100. Thus, a higher score on distractors signifies more errors.

| | | | P | | |
|---|---|---|---|---|---|
| | C<br>(N=232) | E<br>(N=2224 | IQ | Block | Treatment |
| **Correct answers** | 48.4<br>(2.2)* | 53.0<br>(2.2) | 0.0001 | 0.0001 | ns |
| **Distractors with same label** | 32.9<br>(2.3) | 39.6<br>(2.3) | 0.004 | 0.0001 | 0.02 |
| **Distractors with similar form** | 35.0<br>(2.2) | 38.9<br>(2.3) | 0.01 | 0.002 | ns |

*Standard error

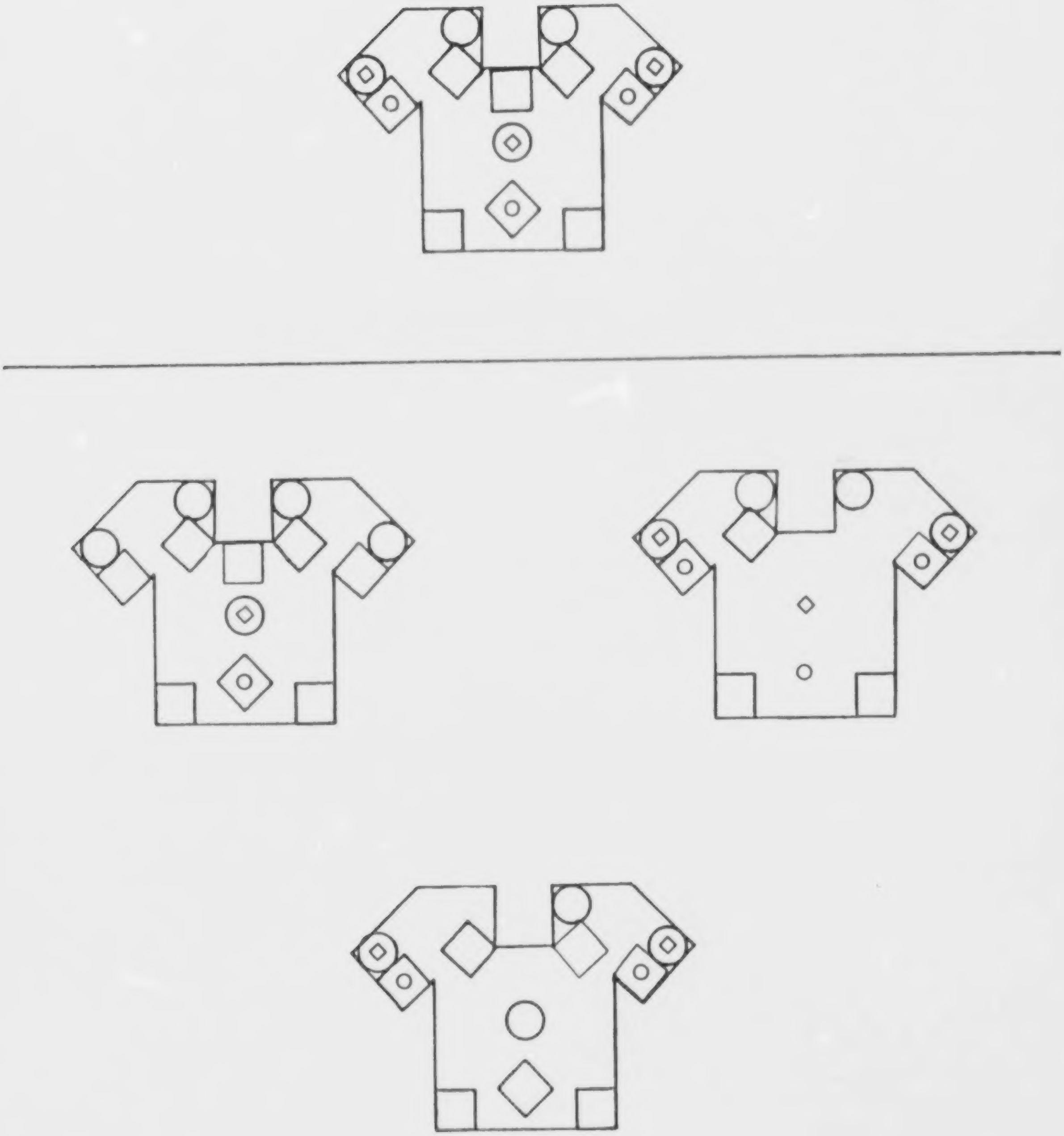


Figure 6.2
Complex Reproduction
In this task (E3), students were shown the drawing of a shirt (above the horizontal line) and asked to fill-in the missing shapes in the three other shirts (below the line).

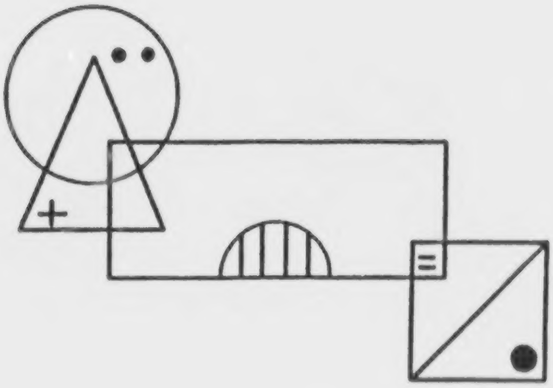


Figure 6.3

The Rey Task

Students were first asked to copy a complex shape (F4). Next, they were asked to turn over the page and to reproduce the shape from memory (F5).

better savings of the Agam-trained children.

## B. VISUAL LEARNING

As mentioned in the previous chapter, the ability to learn new visual tasks was tested via a series of three tasks of drawing a tree on a slope (see Figure 6.4). This task is reported to cause difficulties to children because of the "vertical effect,", i.e., the tendency to draw the tree perpendicular to the slope (Freeman, 1979).

In this task, the child is asked to make three consecutive drawings (see Figure 6.4). In the first and the last drawings, the child is briefly shown a flash card of a "tree on the side of a mountain". Given a drawing of the "mountain" (see stimulus 1 in Figure 6.4) the child is asked to copy the tree. For the second drawing, the child copies a picture with the accurate drawing of the tree on the slope (see stimulus 2 in Figure 6.4).

We hypothesized that the "vertical effect," like field dependence, is strongly rooted in the child and would not be affected by the program. However, we expected that after receiving some visual experience with the task, children trained in the Agam Program would gain more from their experience and would be able to provide a somewhat more accurate drawing.

As expected, the vertical effect was evident in children's drawings and the lines they drew were oriented between the correct direction (147 degrees relative to the slope) and the orientation perpendicular to the slope. The average deviation in degrees from the correct orientation in the three tasks is given in Figure 6.5. The figure indicates a reversal of the initial advantage of the comparison group to a consistent advantage of the Agam-trained children. The fact that initially the experimental children were no better than the comparison children seems to indicate that the experimental children did not have a prior familiarity with the task, either through direct training or through transfer from other tasks. The experimental children were, however, better prepared to learn and absorb the new visual knowledge. Their drawings were significantly better than those of the comparison group ($p<0.002$).

It is interesting to note that although the correct drawing was in front of their eyes (on the same page) children still were strongly influenced by their internal image and slanted the line towards the perpendicular. Thus, as can be seen from table 6.2, no improvement whatsoever can be seen in the comparison group, from trial 1 to 2, but there is a significant improvement of about 15 degrees in the

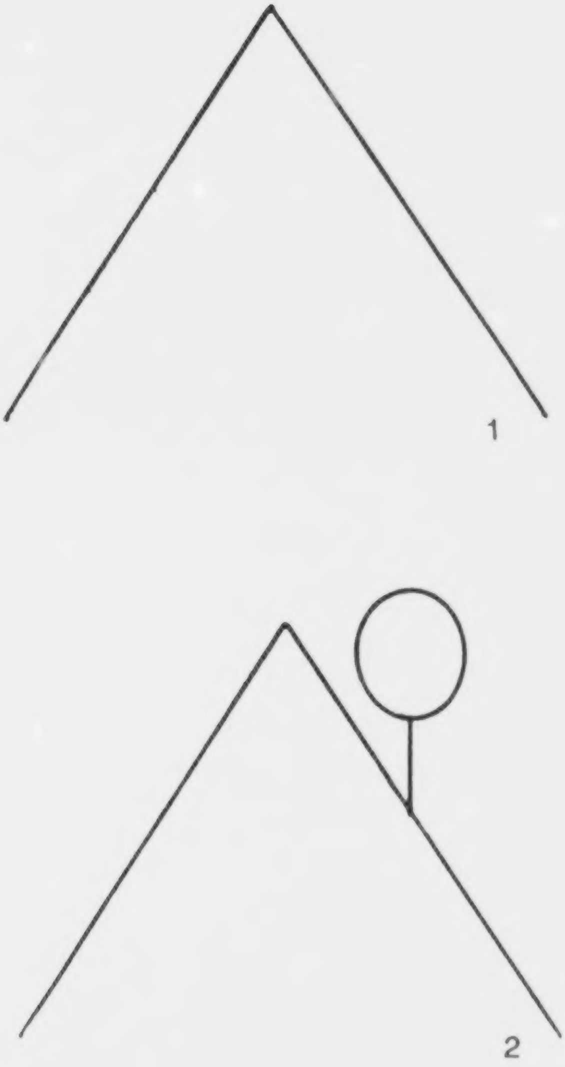


Figure 6.4

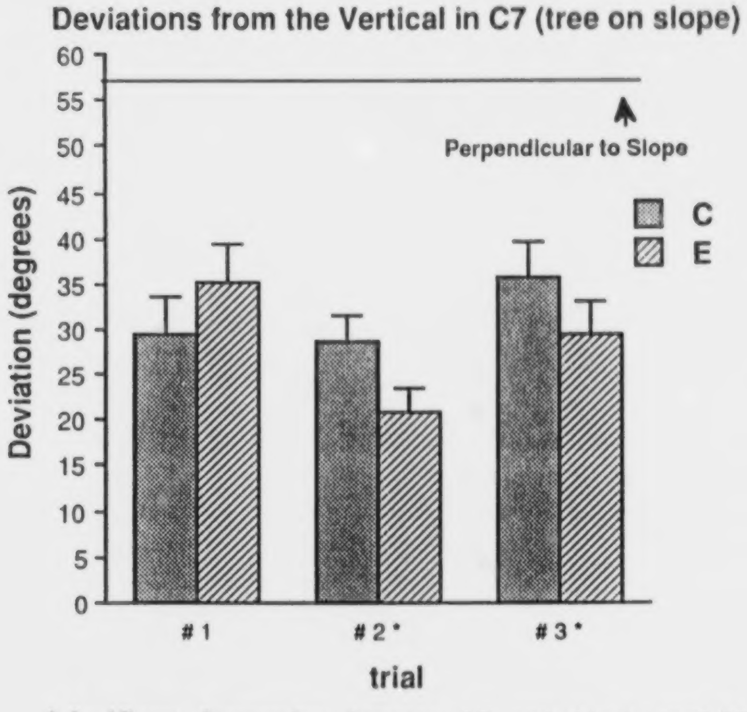
Tree-on-the-Slope Task (C7)

In the first trial, children were given the shape of a pointed mountain (1). They were briefly shown a flash card (2) and asked to copy the "tree" on the right side of their mountain. In the second trial, children were given the shape of a pointed mountain (1), and were shown the "tree-on-the-mountain" for a long time. The third trial was a repetition of the first.

Table 6.2: Adjusted means of difference between deviations (in degrees) from correct orientations in task C7. The means are adjusted for IQ and block. The three parts of the task are shown in Figure 6.4.

| Trials | C (N=77) | E (N=82) | P | | |
|---|---|---|---|---|---|
| | | | IQ | Block | Treatment |
| #2-#1 | -0.6<br>(3.6)* | -14.6<br>(3.5) | ns | ns | 0.003 |
| #3-#1 | 6.5<br>(4.7) | -5.9<br>(4.5) | 0.006 | ns | 0.03 |

*Standard error



*significant interaction bewteen IQ and block (p<0.001)

Figure. 6.5

Tree-on-the-Slope Task (C7)
Adjusted means of deviations (in degrees) from the correct orientation of the tree towards the perpendicular to the slope (represented by the horizontal line). Means are adjusted for IQ and block.

experimental group ($p<0.003$). In the third trial, where again the children received no assistance, children in the comparison group demonstrated an even poorer performance than in the initial drawing. The Agam-trained children regressed in their performance relative to the copying task but still retained a statistically significant advantage ($p<0.03$).

Similar significant results were obtained in a previous study of the Agam Program, with a similar task and a different sample (Razel & Eylon, 1989). In that study, the similar task was drawing of the water level of a bottle slanted at a 45-degree angle (this task is used to evaluate field-dependence). Similar to the task in the present study, children tended to be influenced by the field and mistakenly slanted the water line towards a line parallel with the the bottle's bottom.

After the children drew the water level without particular assistance, they were given four similar training tasks. The first and the second of these were drawing the water levels in pictures of a vertical and a slanted bottle, respectively, while an actual bottle containing coloured water was presented to the child in the vertical and then slanted positions. The third and fourth tasks were simply copying from juxtaposed examples which pictured the water levels in a vertical and slanted bottle, respectively. Finally, the children again drew the water level in a slanted bottle without assistance. An initial advantage of the comparison group was reversed to a consistent advantage of the Agam-trained children.

These results suggest two conclusions in comparing children in the Agam Program with children in the comparison group:

(1) Agam-trained children have better observational skills. Thus, given a visual stimulus which contradicts their internal image, they can better reproduce the stimulus.

(2) These children can learn better from their visual experience, as is evident in the improvement of their later drawings, compared with the first ones.

## C. MATHEMATICAL READINESS

The Agam Program can potentially contribute to several aspects of mathematics learning. Its most direct potential contribution is to the study of geometry. This is achieved by forming an intuitive basis for understanding geometrical concepts, and by training children in skills that are important in the study of geometry (e.g., flexibility in perception). It should be noted that these skills are trained within the context of the geometrical concepts. Another potential contribution is to the study of some logical notions through the study of visual patterns. Finally, the program may contribute to mathematical reasoning which involves visual stimuli as useful representations of concepts (e.g., addition and subtraction).

As demonstrated in the previous chapter, children trained in the Agam Program gained a more robust understanding of basic geometrical concepts and performed various visual skills better than the comparison children. The results concerning the concept of "patterns" showed that children in the Agam Program attained a higher level of understanding as compared with children in the comparison group. In this section, we present additional data regarding the acquisition of visual flexibility in the Agam Program.

In the final test, children were given six drawings identical to the one showed in Figure 6.6 ( task F8). They were asked to trace in each drawing a different geometrical shape which contained the heavy line. To help children understand this task, they were asked to imagine that they cut with scissors different shapes that include this line. This task calls for visual flexibility commonly required in the study of geometry. The distribution for the number of correct drawings is shown in Table 6.3. The coding scheme for task F8 is given in appendix 3.

## D. INTELLIGENCE

### 1. Research Results

To obtain the most reliable index of intelligence for each child, the scores on all intelligence tests that were administered to him during the pretest, i.e. the WPPSI, Raven's Coloured Progressive Matrices, and the Draw-a-Man test, were averaged to yield a composite intelligence score. The same was done for the tests administered during the posttest, i.e., the Raven and Draw-a-Man tests. Next, the mean composite intelligence score in the experimental and comparison group was computed. In the pretest, this mean was 95.1 and 98.3 for the experimental and comparison groups, respectively. Finally the average change form pre- to post-test was computed in the experimental and comparison groups.

The results were that the experimental children improved an average of 5.7 IQ points from pretest to posttest. This improvement was statistically significant ($t = 5.84$,

Table 6.3: Percentages of children drawing the various number of different and correct shapes in task F8. The mean number of shapes is adjusted for IQ and block.

| # Shapes | C (N=91) (%) | E (N=94) (%) | |
|---|---|---|---|
| 0 | 6.6 | 2.1 | |
| 1 | 15.4 | 8.5 | |
| 2 | 18.7 | 11.7 | |
| 3 | 7.7 | 8.5 | |
| 4 | 13.2 | 20.2 | |
| 5 | 24.2 | 25.5 | |
| 6 | 14.3 | 23.4 | |
| **Adjusted Mean of # Shapes** | 3.4<br>(0.17)* | 4.0<br>(0.16) | p<0.004 |

*Standard error

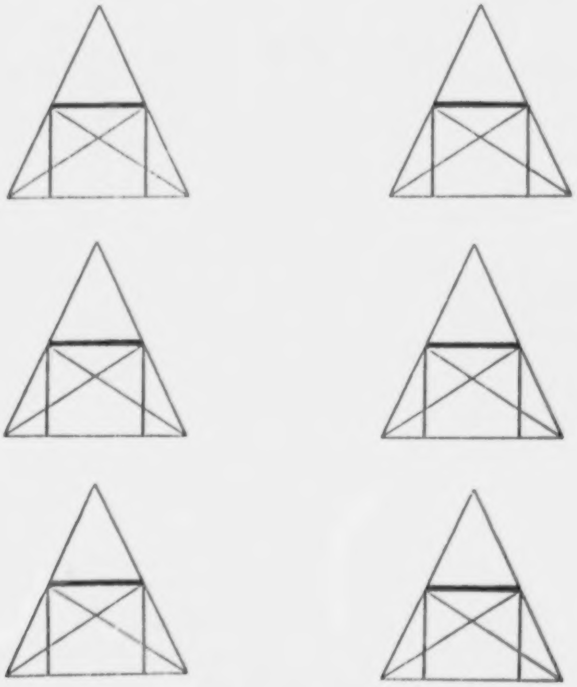


Figure 6.6

Visual Flexibility Task (F8)
Using the above drawings, children were asked to trace as many different shapes as they could. Each shape had to include the thick line in the drawing.

$p<0.0001$). The comparison group, on the other hand, did not improve from pre- to post-test, the average difference score being a negligible 0.1 IQ point ($t = 0.10$, a statistically nonsignificant result). Not surprisingly, a comparison of the improvement in the experimental group and that in the comparison group yielded a statistically significant result ($t = 4.09$, $p <.0001$). The findings thus indicate that a two-year-long exposure to the Agam Program resulted in an improved performance on the intelligence tests.

## 2. Discussion

It was found that the intelligence score of the children who were trained in the Agam Program improved over the two-year training period by about six IQ points while the intelligence of the comparison children did not change over this period of time. These findings replicate what was found in a study of the first two-year implementation of the Agam Program in five experimental and five comparison classes (Razel & Eylon, 1990a, 1990b). The fact that the finding was replicated implies that this finding was not an artifact due to chance effects, but is a robust and real phenomenon. Razel and Eylon (1990) considered the question whether the improved intelligence scores of the Agam-trained children was a matter of test performance only, or whether it indicated an underlying improvement in the children's intelligence. These authors concluded that the latter possibility was the more likely one, considering (a) that the Agam Program represents a long-term educational intervention and (b) that the Agam Program does not purposefully prepare the children for items included in intelligence tests.

The general implication of this finding is that training in the Agam Program affects the child beyond the specific tasks in which training is given by the Program. What the experimental children learned in these tasks transferred to the completely novel tasks presented to them in the intelligence tests. This finding lends support to the hypothesis that the Agam-trained children will be better equipped to cope also with other novel tasks that they may encounter during their lives than children who did not receive training. A somewhat different way of looking at this finding, which may in fact be no more than a different phrasing of the same conclusion, is that the Agam Program in its specific tasks, trains general thinking and intellectual skills that are useful for life and are tapped also by intelligence tests.

## E. CREATIVITY

Creativity was measured by two different tasks. One task was included in the circle/square test. Three squares of different sizes were given in the test booklet and the children had to draw as many different combinations as they could. They were provided with space for 12 compositions. Figure 6.7 shows the results for this task. Children in the Agam Program were able to draw many more different combinations than children in the comparison group. The average number of drawings in the comparison group was 1.7 vs. 3.5 in the Agam group ($p<0.00005$).

The other task was given in an interview at the end of the two years to a subgroup of children. This task is parallel line activity (#3) of the Torrence Test (Torrance, 1974). Children were given, eighteen times, the same pair of parallel lines and were asked to draw a picture that included these two lines. Several scores were obtained:

(1) Fluency: the number of different (relevant) responses.

(2) Flexibility: the number of different categories into which the subject's response can be classified

(3) Originality: children get points (1-3) on the basis of the occurrence of their drawing among the drawings of 500 subjects from kindergarten through college (e.g., 3 points are credited to a drawing that occurs in less than 2% of these drawings).

(4) Bonus: bonus is given when children combine two or more sets of drawings, the more sets being combined, the higher the bonus.

(5) Elaboration: the number of ideas communicated by the child in addition to the minimum basic idea (e.g., a bus and a child in it).

The mean scores are given in Table 6.4. Overall, there was no significant difference between the performance of the two groups. The comparison groups scored better in the fluency and the originality scores, while the Agam children were better in the elaboration score. No significant differences were found in the flexibility and bonus scores.

Another task which involved free composition of patterns (B1) was discussed in the previous chapter. As was described, the patterns that children in the Agam Program drew were more complex and more imaginative. Most of the

Table 6.4

Adjusted means on the "parallel lines task" in the Torrance test of creativity. Means are adjusted for IQ and block.

| | C | E | P | | |
|---|---|---|---|---|---|
| | (N=47) | (N=50) | IQ | Block | Treatment |
| **Fluency*** | 11.1<br>(0.6)** | 8.8<br>(0.6) | 0.004 | 0.0001 | 0.004 |
| **Flexibility*** | 7.6<br>(0.4) | 7.0<br>(0.3) | 0.0001 | 0.0001 | ns |
| **Originality*** | 14.4<br>(1.1) | 11.5<br>(1.1) | 0.003 | 0.0004 | 0.03 |
| **Elaboration** | 0.6<br>(0.3) | 1.6<br>(0.3) | ns | 0.03 | 0.008 |
| **Bonus** | 0.4<br>(0.3) | 0.7<br>(0.3) | ns | ns | ns |
| **Average*** | 34.2<br>(2.0) | 29.7<br>(1.9) | 0.0004 | 0.0001 | ns |

*significant interaction between IQ and block ($p<0.04$ or less)
**standard error

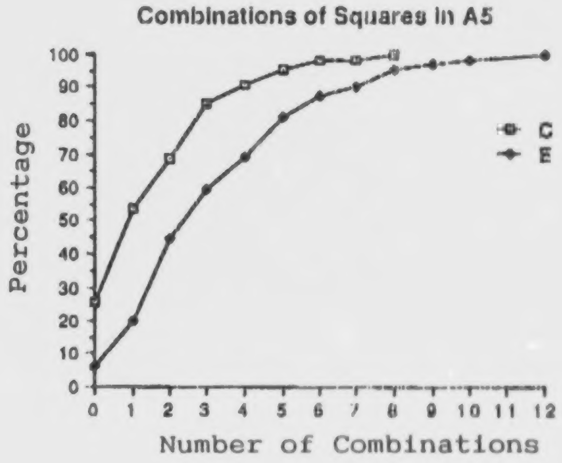


Figure 6.7

Number of different combinations of three squares drawn by children in task A5. The graph show cumulative percentage. N(C)= 125 and N(E)= 107 children in the comparison group drew patterns composed of one element (e.g., a series of squares).

## F. STUDENT CHARACTERISTICS

To see whether the Agam Program affects differently children with different characteristics the children in both the experimental and comparison group were subdivided into the following categories: (a) boys vs. girls; (b) underpriviledged vs. priviledged children (this division was based on a classification of the child's preschool according to the socio-economic status of the population that it served); (c)#children with high vs. low nonverbal intelligence (obtained by combining the child's scores on the Raven, Draw-a-Man, and performance subtests of the WPPSI); (d) children with high vs. low verbal intelligence (based on the verbal subtests of the WPPSI); (e) children who were "more nonverbal than verbal" vs. those who were "more verbal than nonverbal" (based on a higher nonverbal intelligence score than a verbal score -- as defined in (c) and (d) -- or vice versa).

To obtain the most reliable measure of performance on which to compare the subgroups of children, the performance on several tests was combined into one score. The tests that were included in this process of combination were: (a) "Circle and Square", (b) "Patterns", (c) "Orientations", (d) "Summary Test 1986", (e) "Pretest 1987", (f) "Individual Test" and (g) "Summary Test 1987" (see Chapter IV for details). The process of combination included the following two steps. First, the scores of all the items on each test were combined into one score. Next, these total scores were transformed into $\underline{z}$, or standard, scores in order to make them comparable in term of mean and standard deviation. These $\underline{z}$ scores were then combined in a total performance score. The subgroups of children with different characteristics were compared on this total performance score.

The results of this analysis are given in Table 6.5. These results indicate that the over-all test performance of girls was somewhat better than that of the boys. This superiority of the girls did not, however, reach statistical significance in a two-sided t-test. It seems that a one-sided t-test is not justified since there is no apriori hypothesis that girls should have higher achievements in the Agam Program. It should be noted, however, that a tendency for girls' superiority, that did not reach statistical significance, was also found in Razel and Eylon (1990a, 1990b).

The over-all test performance of under-priviledged children

## Table 6.5

## Over-all Test-Performance in Different Subgroups

| Subgroups A/B | Subgroup A | | | Subgroup B | | | Subgroup Difference t Values | Experimental -Comparison X Subgroup Interaction F Values |
|---|---|---|---|---|---|---|---|---|
| | Mean | N | SE | Mean | N | SE | | |
| Boys/Girls | 0.02 | 296 | 0.04 | 0.10 | 259 | 0.04 | -1.71 | 0.09 |
| Priviledged/Under-priviledged | 0.19 | 162 | 0.06 | -0.06 | 239 | 0.05 | 3.96** | 0.31 |
| High/Low Nonverb. Intel.[a,b] | 0.34 | 42 | 0.09 | -0.41 | 41 | 0.09 | 4.39** | 0.27 |
| High/Low Verb Intel.[a,c] | 0.20 | 40 | 0.10 | -0.25 | 43 | 0.10 | 2.57** | 1.08 |
| Higher/Lower Nonv. than V. | -0.003 | 54 | 0.06 | -0.006 | 29 | 0.09 | 1.39 | 0.08 |

[a] These analyses were performed without the covariate.

[b] Based on the average score on the nonverbal subtest of the WPPSI, the CPM, and the Draw-a-Man.

[c] Based on the verbal subtest of the WPPSI.

**$p < .01$

apriori hypothesis that girls should have higher achievements in the Agam Program. It should be noted, however, that a tendency for girls' superiority, that did not reach statistical significance, was also found in Razel and Eylon (1990a, 1990b).

The over-all test performance of under-priviledged children was, not surprisingly, significantly poorer than that of priviledged children. The interesting finding, however, was the lack of interaction between being priviledged or not, and having been trained by the Agam Program or not. The means in the four groups, on which this finding of no interaction is based, are presented graphically in Figure 6.8. The two lines that connect these means are practically parallel, indicating that the under-priviledged children gained just as much from the Agam Program as their priviledged peers.

The figure also shows that the provision of training in the Agam Program to the under-priviledged children more than closed the gap between them and normal priviledged children who did not receive this training. The apparent superiority of the experimental under-priviledged group over the comparison priviledged group did not, however, reach statistical significance. These findings concerning priviledged and under-priviledged children replicate findings obtained in an earlier study (Razel & Eylon, 1990).

Other findings provided in Table 6.5 indicate a superiority of those children with a higher intelligence (either nonverbal, or verbal) over those with a lower intelligence. Again, no interaction was obtained between having a high or low intelligence, and belonging to the experimental or comparison group. In other words, low intelligence children gained from studying in the Agam Program just as much as high intelligence children

The last line in Table 6.5 shows that children with a verbal or nonverbal inclination performed equally well in the Agam Program. The lack of interaction shows also that no one of these two subgroups gained more from participating in the Program than the other subgroup. These findings replicate and support earlier findings of the Agam Project (Razel and Eylon, 1990).

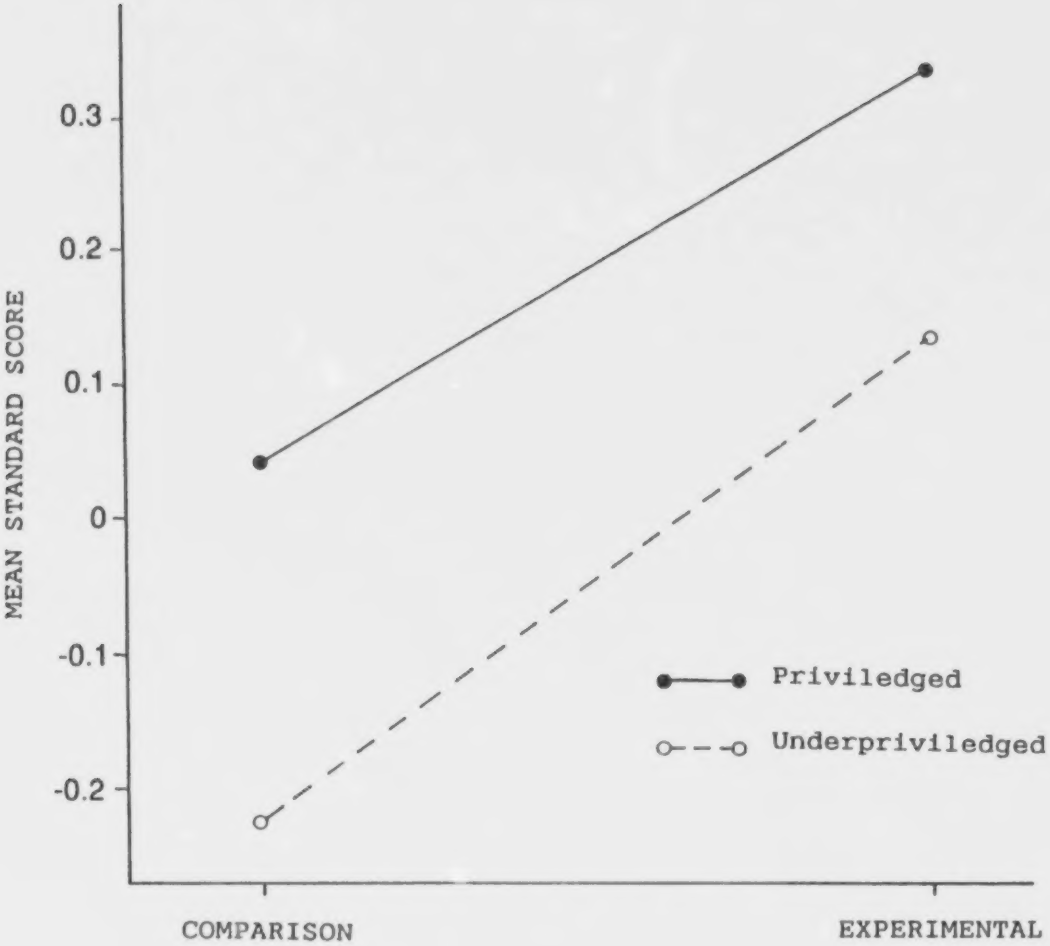


Figure 6.8

Over-all transfer effects of the Agam Program for experimental and comparison children from priviledged and underpriviledged towns.

# VII. CHILDREN'S PERCEPTIONS

## A. BACKGROUND

One of the most reoccuring observations of the research staff was that the children participated enthusiastically in the Agam Program. Likewise, the teachers repeatedly reported how much the children seemed to enjoy the program's activities. For example, it was common to see children run eagerly to their small-group sessions, to observe them enthusiastically participate in the activities, and to hear some of the children express their disappointment when told that their Agam activity time was over.

The research staff took an interest in probing this phenomenon more closely. Staff observations and teachers' anecdotal reports, while valid in their own right, seemed to neglect two important aspects. On one hand, they were not always based on what the children themselves had to say. More significantly, they did not permit a reliable, fine-grained analysis and comparison of the children's activity preferences.

This last point is especially important given the highly-structured nature of the Agam Program, which integrates concepts with skills (see Chapter II). Thus, in order to fully understand the children's attitudes and preferences, it seemed necessary to study their responses not only to the different booklets (or concepts), but also to the different activity categories (or skills).

Given the above, one would like to develop a reliable instrument with which to study the following questions:

1. What do the children think the Agam Program is?

2. What do they specifically like and dislike about it?

3. What do they feel are the benefits of learning this program?

4. What are their preferences regarding the booklets and the varied activities?

5. How varied are the distributions of the responses to questions #1-4? Is there unanimity, a wide range of responses, or a moderate amount of variability? Do certain groups of children respond differently than other groups?

The major difficulty in undertaking this study is obvious: young children are limited in their skills of verbal understanding and verbal expression. How might a reliable instrument be designed which circumvents this difficulty, while providing the capacity to investigate in detail the questions raised above?

## B. METHODS

One way to circumvent a young child's limited verbal language ability -- taking a hint from the Agam Program -- is to utilize the visual language.

We designed a research instrument based on a number of drawings, to which the young children were asked to respond. In addition, we employed the projective technique, asking children to answer how another child of the same sex would respond to the various situations; use of the projective technique makes it easier for subjects, especially children, to answer in ways which might otherwise be suppressed (e.g., giving a highly negative reaction, which may be seen by the child as offensive to the adult asking the questions).

The visual projective attitude test was divided into two sections:

### Section One

(a) The child is shown a picture of a child speaking to his/her first-grade class. Question: "Here you see a boy/girl who has finished the Agam Program talking to his/her first grade class about the Agam Program. They don't know what is the Agam Program. What is he/she telling them?"(see Figure 7.1)

(b) The same picture is shown. Question: "What is he/she telling them that he/she especially liked in the Agam Program? What is he/she telling them that he/she especially disliked in the Agam Program?"

(c) The child is shown pairs of drawings. In each pair, the drawings are identical, except for one change: the child's hair color. Question: "Here you see a child who has finished the Agam Program and is in first grade. And here you see a child who was not in the Agam Program and is in first grade. As you can see, they are both ---------- (the activity in the picture is then described). Which child, do you think, will do better? The child who was in the Agam Program? The child who was not in the Agam Program? Or do you think there won't be a difference?" After the child answers, the tester asks: "Why do you think so?" Pairs of pictures

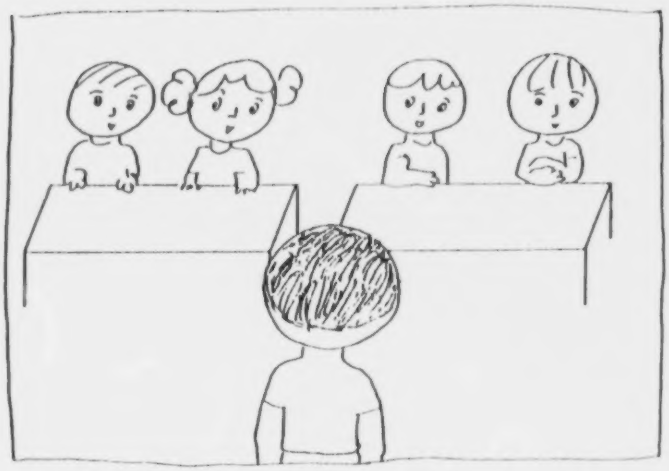


Figure 7.1

Show and Tell

The child is asked: "Here you see a boy/girl who has finished the Agam Program, talking to his/her first grade class. What is he/she telling them?"

involve children (a) learning to read, (b) learning to write, (c) learning arithmetic, (d) drawing, (e) making decorations for their class, (f) organizing a birthday party, and (g) playing various games in the birthday party.

## Section Two

(a) Activity Preferences. The subject is shown 5 drawings of the face of child; these 5 faces show different emotional states, from a complete frown to a complete smile (see Figure 7.2). Question: "These pictures show a child who finished the Agam Program. Notice that here he/she is very happy, (tester points to face with complete smile) and here (tester points to face with complete frown) he/she is very unhappy. I will show you some drawings of activities from the Agam Program. With each drawing, point to the picture that shows how the boy/girl felt about that activity." The tester shows the drawing and asks the subject to describe what is happening. If the child doesn't know, the interviewer points out what is happening in the drawing. After subject chooses a face, the interviewer records the response and shows a new drawing.

(b) After all the drawings have been seen and categorized by the child, the interviewer asks the child to order the drawings associated with each face, from "liked best" to "liked least."

(c) During and after this process, the tester would ask the child to explain the reasons for his or her choices, especially where the child responded differently to two similar drawings. These comments are noted in the score sheet.

(d) The research plan associated with the Activity Preferences is shown in Figure 7.3. The drawings were chosen to represent specific booklets and specific activity categories. Two test forms were given: Form A (composed of drawings from the Triangle and Ornaments booklets) and Form B (composed of drawings from the Oblique and Combination of Circle, Square and Triangle booklets. In addition, four "control activity" drawings were given in each test form: children playing in the playground, teacher reading a story to children, child drawing at home, and child playing with blocks.

The activities in Figure 7.3 (on the horizontal axis) represent generic activity types. Each booklet in the Agam Program is divided into three broad groups of activities: identification (ID), memory, and reproduction. Within these categories there are

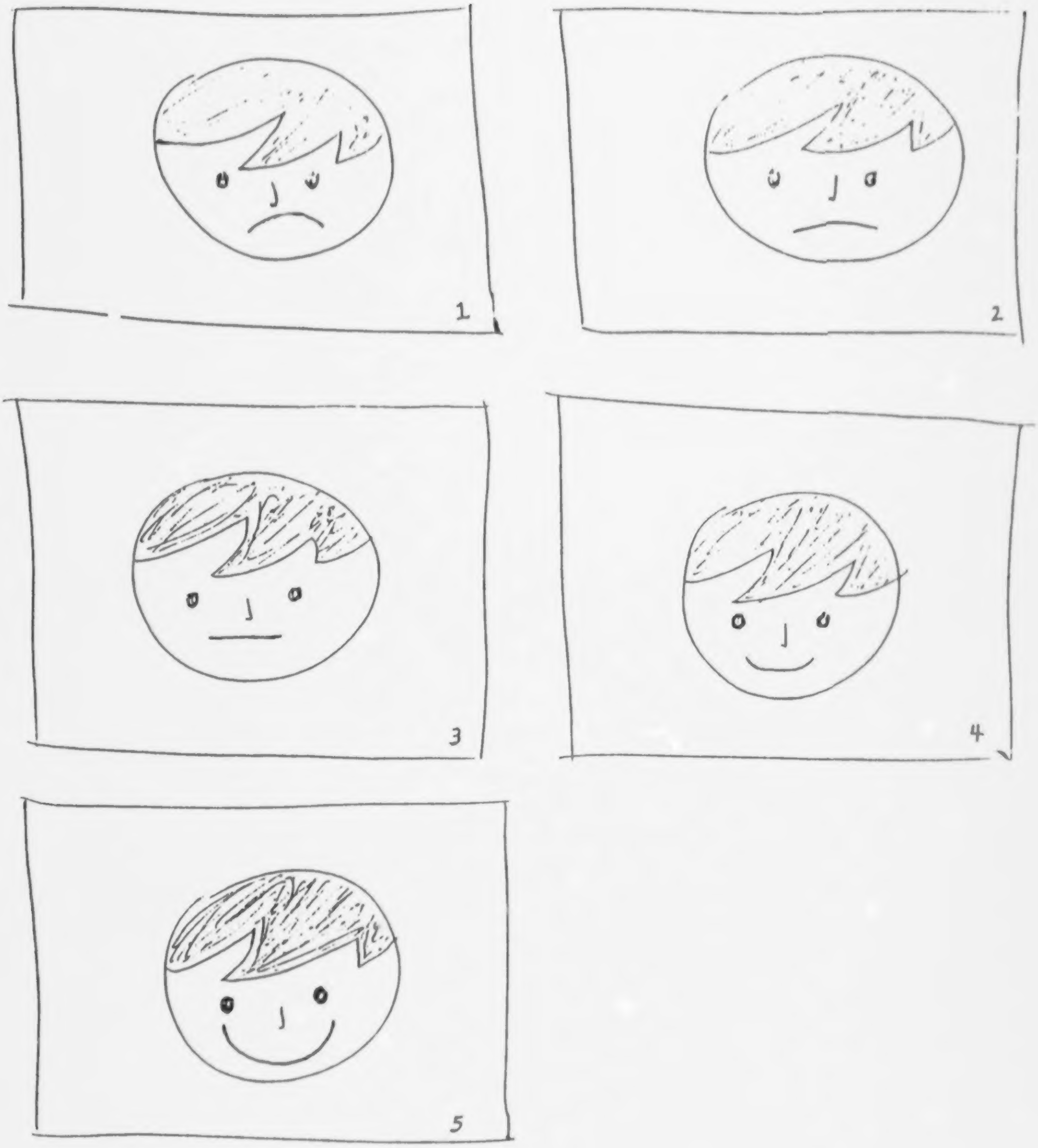


Figure 7.2

Face Preference Gradient

A child was told that the boy/girl in the drawings had been in the Agam Program. The child was then shown drawings representing a specific activity and asked: "How does the boy/girl feel about this activity?" Responses were graded from 1 (face with frown) to 5 (face with smile).

ACTIVITIES →

| | BOOKLETS ↓ | I.D. | | FROM CONCEPT TO OBJECT | MEMORY CARDS | | RERODUCTION | | | | | | REPRODUCTION FROM MEMORY | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Teacher Shows | Child Shows | | Teacher Shows | Child Shows | Graphic | Transp. | Forms | Body | Group | Creativity | | |
| △ | TRI. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | 10 | 11 | A |
| ●■●■ | ORN. | | | 12 | | | 13 | | | | 14 | 15 | 16 | |
| / | OBL. | 17 | 18 | 19 | 20 | 21 | 22 | | 23 | 24 | | 25 | 26 | B |
| □○△ | COMB. | | | 27 | | | | 28 | | | 29 | 30 | 31 | |

Figure 7.3

Research Plan

This matrix reflects the structure of the Agam Program, which integrates specific concepts (y-axis) with specific skills (x-axis). The numbers (1-31) represent activity cards shown to the children. Each child was given one of two possible tests (A or B).

CONTROL ACTIVITIES

| | |
|---|---|
| 32 | Children Playing in Playground |
| 33 | Teacher Reading Story to Children |
| 34 | Child Drawing At Home |
| 35 | Child Playing With Blocks |

> variations. Thus, a child or the teacher can illustrate an identification activity, where the central concept of the booklet is demonstrated. Children or teachers can also present the memory "flash cards" to the students. In "from concept to object" activities, the children search for examples of the concept (e.g., patterns) in a given environment. Reproduction activities can involve transparencies ("transp."), plastic geometric forms ("forms"), an individual's physical activity ("body"), the physical activity of a group of children ("group"), or a pencil ("graphic"). Open-ended reproduction activities ("creativity") involve materials such as paper (cutting and pasteing) or clay. In "reproduction from memory" activities, children graphically reproduce what they see after "flash cards" have been presented.

The sample consisted of 21 preschool children who participated in the Agam Program for two years; they were 5- and 6-year olds. The children were randomly chosen to represent each sex and three intelligence groups according to their WPPSI scores (i.e., high, medium and low scorers).

## C. FINDINGS

1. When asked to explain "What is the Agam Program?," the children invariably answered in descriptive and concrete terms.

In describing what the child would tell his first-grade class, one child said, "The boy would tell them about the horizontal, about the vertical, and he would tell them what's a line of symmetry, the axis of symmetry, and all sorts of things," said one child. "But what is the Agam Program?" continued the interviewer. "I don't know," replied the child. Each child answered in terms of what he or she had done in the program. A typical response is as follows: "He will show them the shapes... He will teach them and they will know as well as he does."

About a third of the children responded in first-person (e.g., "I will tell them to take a paper and draw lines on it: oblique, horizontal. I will teach them like this. Draw a horizontal line and tell them to cut it.").

2. When asked to describe what they liked and disliked about the Agam Program, there was a wide variety of answers. No one topic dominated in either category. Upon closer examination of the answers, 19 of the 21 children included topics mentioned in their answers to the "What is the Agam Program?" question, when asked to list what they liked best about the program. In other words, when asked to

define the Agam Program, they responded with those activities which they best liked.

3. When asked to predict which child would best succeed in various activities in first grade, the overwhelming majority of the subjects chose the child who finished the Agam Program. The response was about 70% in this direction for reading, writing, arithmetic and drawing (If the subjects were equally divided, the response would have been 50%). On the other hand, the response was lower for decoration, organizing the party, and playing games in the party (from 55-60%). The difference between these two findings is discussed below.

4. The results regarding activity preference are presented in Table 7.1. As noted, on the five-point scale, the average score per activity card ranges from 3.0 to 4.5; the mode (most activity cards for a single score) is 4.1. The four activity cards with the highest averages and the four activity cards with the lowest averages are shown in Figs. 7.4-7.11, along with a drawing of a memory card activity (Fig. 7.12) and control activities (e.g., teacher reading story to children in Fig. 7.13; children playing in the playground in Fig. 7.14). It is worth noting that the Agam Program activities compare very favorably with the control activities, which were explicitly chosen for their high interest for children.

5. In the overwhelming number of activity cards, children gave a wide range of preference values. Only in 4 of the 35 activity cards was the range from 3 to 5. In 24 of the activity cards, the range was from 1 to 5; in 7 of them, the range was from 2 to 5.

6. The mean scores of the children's preferences are recorded in Table 7.2. There was no significant difference between the mean scores for the triangle, ornaments, oblique, or combination booklets, nor for either form of the test. This finding permits us to tally the mean scores for all the activity categories, across both test forms. The results show an interesting bi-modal distribution. Activity categories scoring from 4.0 to 4.3 include the reproduction activities for body, group and creativity, as well as the memory cards. The other activity categories had scores of 3.4 to 3.6; these categories are reproduction activities with shapes, with transparencies, from memory, as well as graphic reproduction and identification activities.

| AVERAGE SCORE | ACTIVITY CARDS | | | | | | |
|---|---|---|---|---|---|---|---|
| 4.5 | 9 | 29 | | | | | |
| 4.4 | 10 | 15 | 33 | | | | |
| 4.3 | | | | | | | |
| 4.2 | | | | | | | |
| 4.1 | 4 | 5 | 16 | 21 | 24 | 25 | 34 |
| 4.0 | 20 | | | | | | |
| 3.9 | 1 | 19 | 35 | | | | |
| 3.8 | 6 | 26 | | | | | |
| 3.7 | 12 | 18 | 30 | | | | |
| 3.6 | 14 | 23 | 28 | 32 | | | |
| 3.5 | 7 | 8 | | | | | |
| 3.4 | 3 | 13 | | | | | |
| 3.3 | | | | | | | |
| 3.2 | 11 | 17 | 27 | | | | |
| 3.1 | 22 | 31 | | | | | |
| 3.0 | 2 | | | | | | |

Table 7.1

Activity Card Averages
Each activity card, numbered as in Figure 7.3, is shown on the same line as its average preference score (see Figure 7.2).

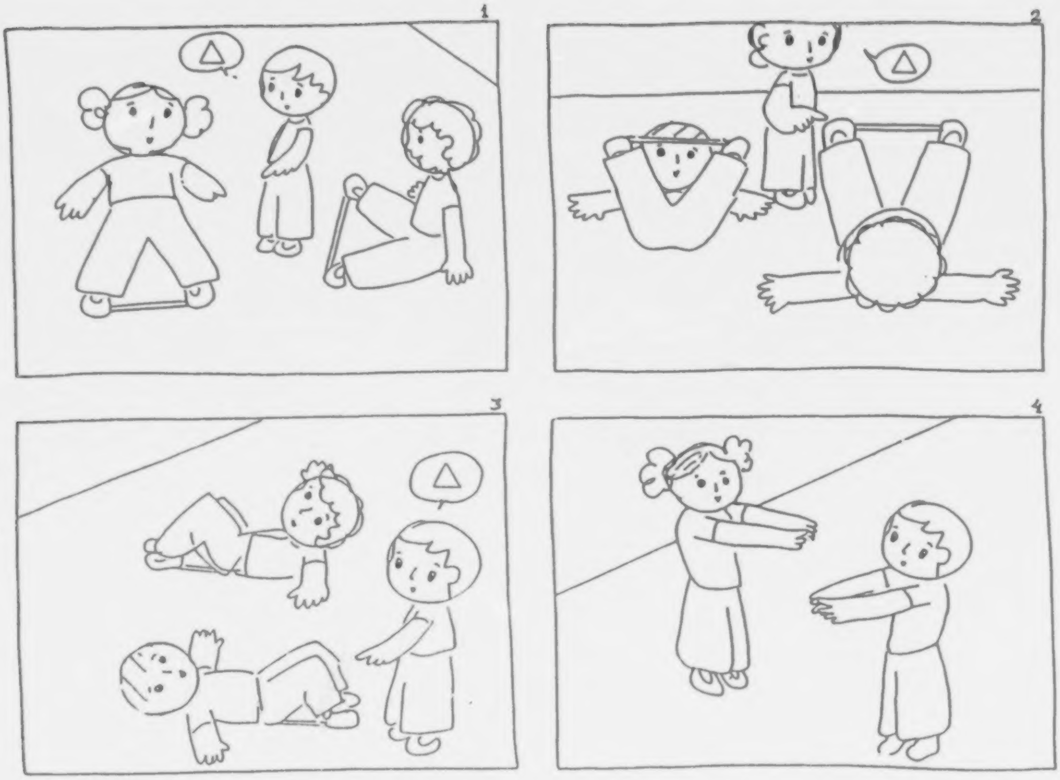


Figure 7.4

Activity Card #9
Children making triangles with their bodies.

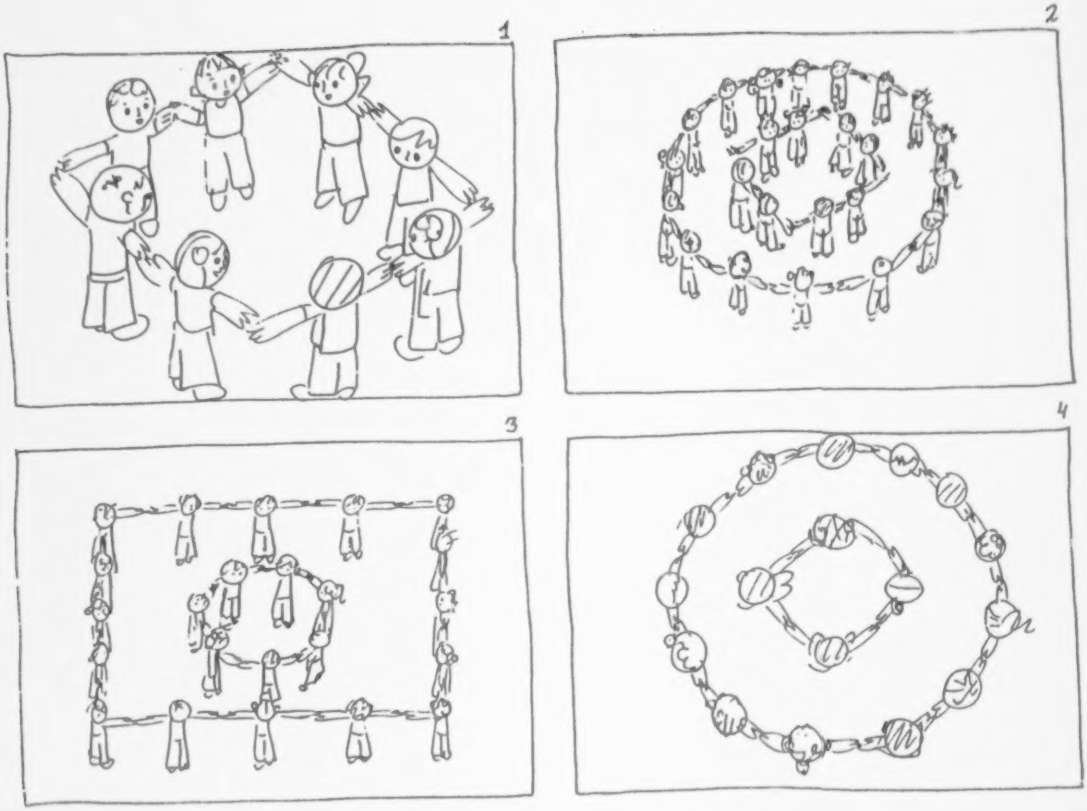


Figure 7.5

Activity Card #29
Children making combinations of a circle and square with their bodies.

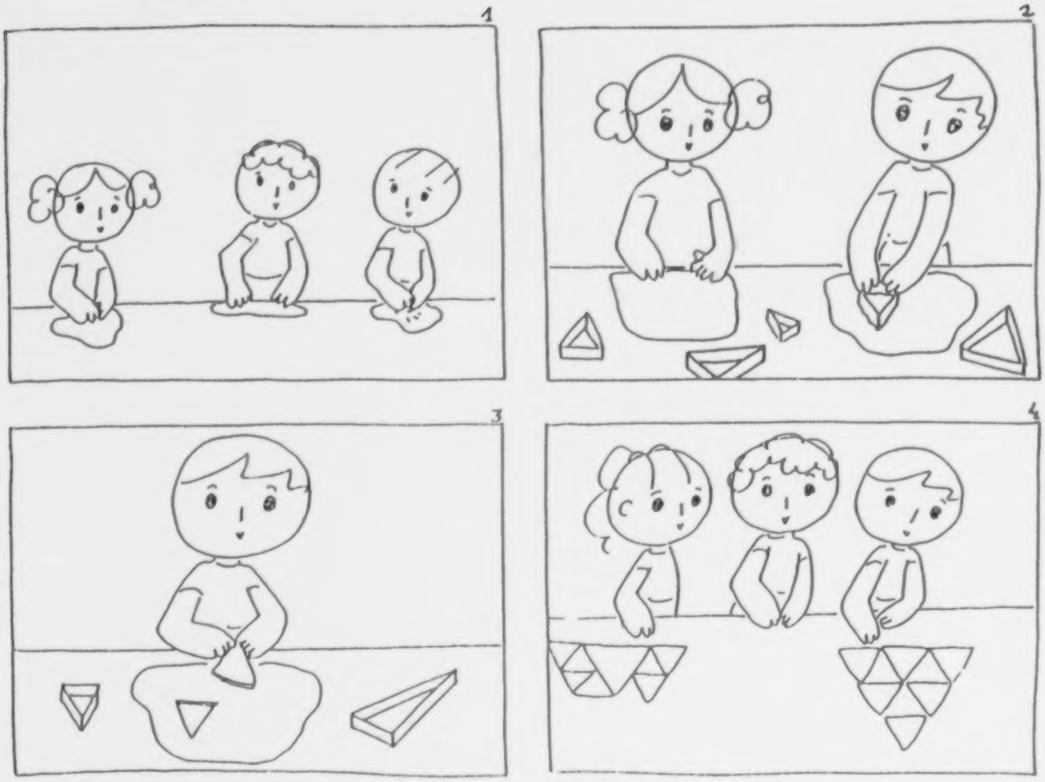


Figure 7.6

Activity Card #10
Creative reproduction of triangles.

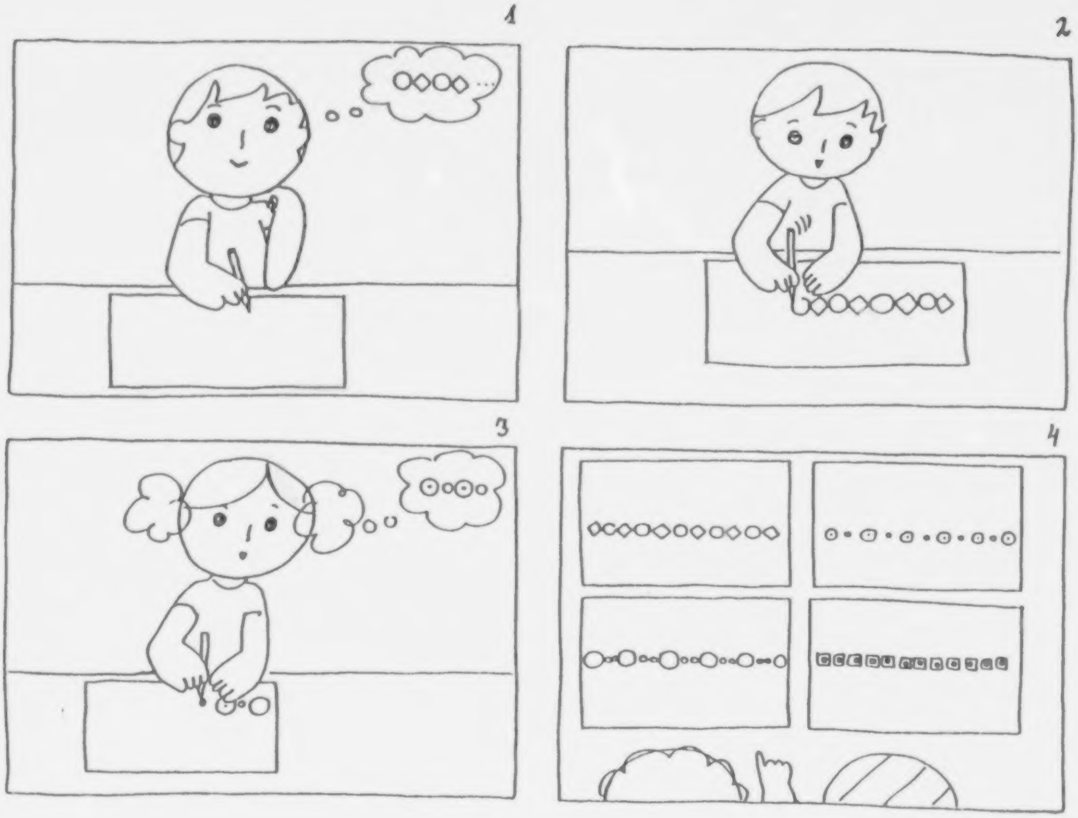


Figure 7.7

Activity Card #15

Creative graphic reproduction of patterns. This activity card received a much higher average preference score, than the activity card for simple graphic reproduction of patterns (#13).

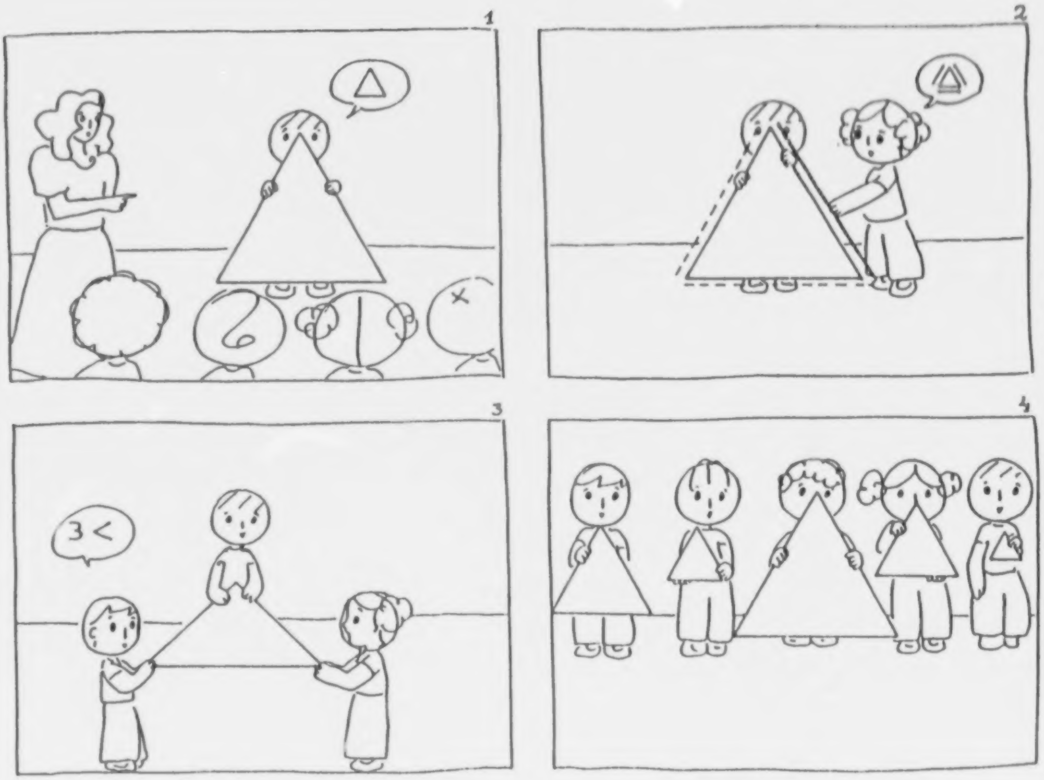


Figure 7.8

Activity Card #2
Identification activity with triangles (child shows).

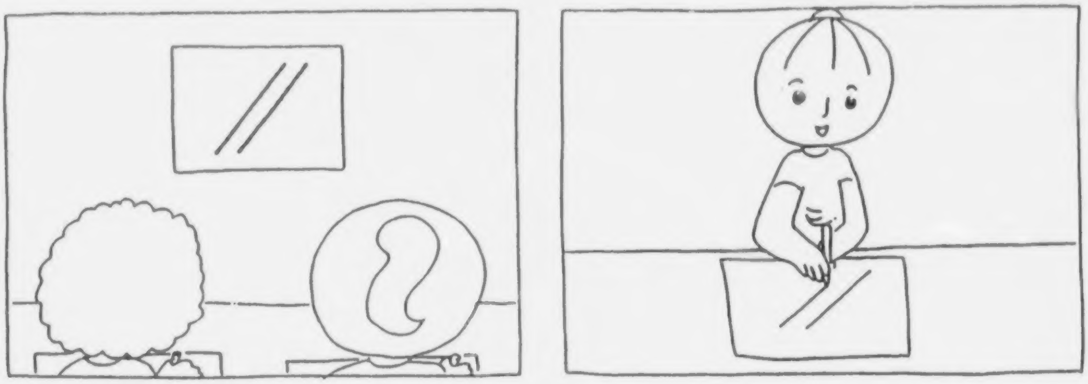


Figure 7.9

Activity Card #22
Graphic reproduction of oblique lines.

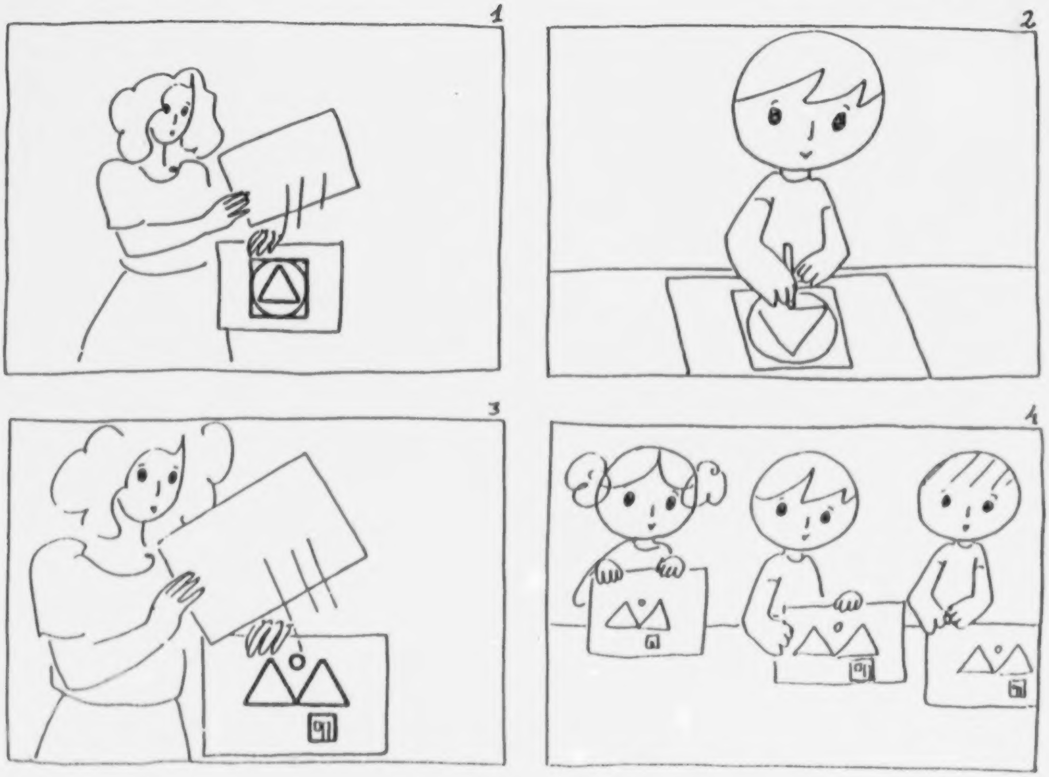


Figure 7.10

Activity Card #31
Reproduction from memory, with combination of shapes.

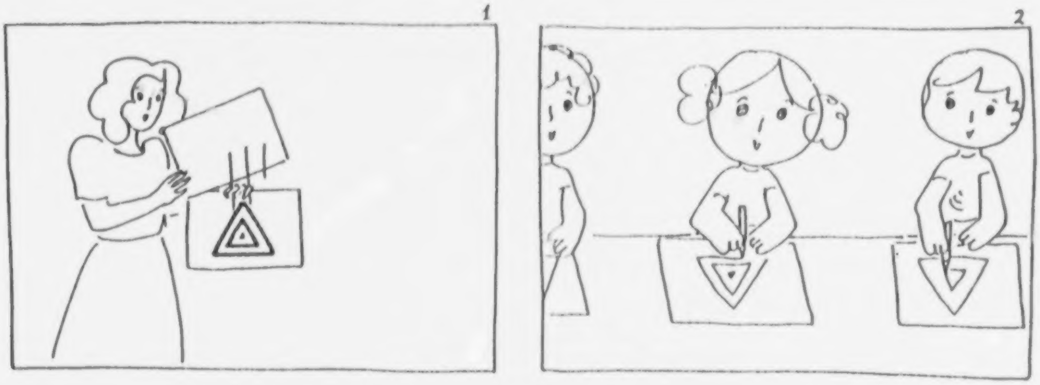


Figure 7.11

Activity Card #11
Memory activity with flashcards (teacher shows).

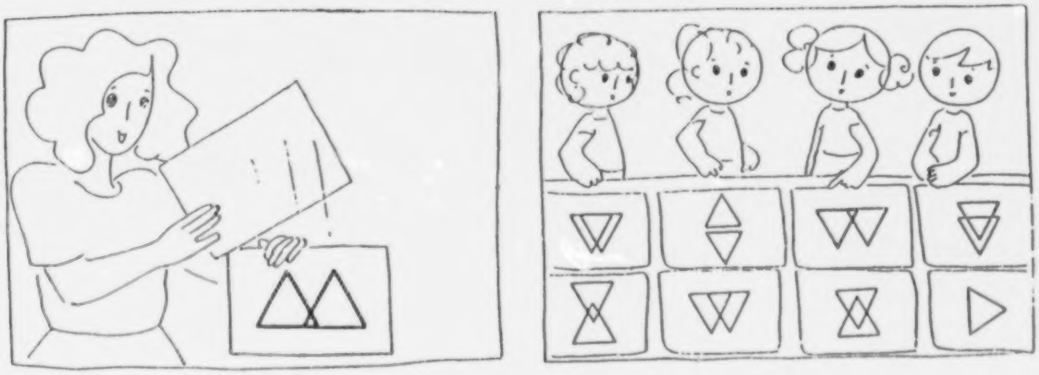


Figure 7.12

Activity Card #4
Memory activity with triangles (teacher shows).

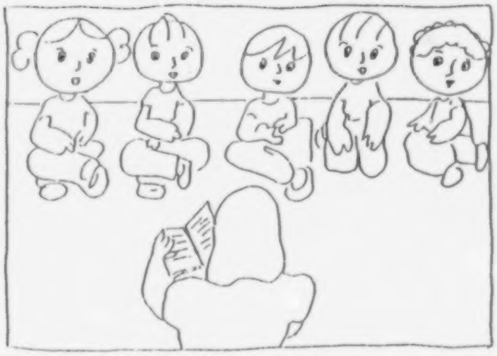


Figure 7.13

Activity Card #33
Control activity:teacher reading story to children.

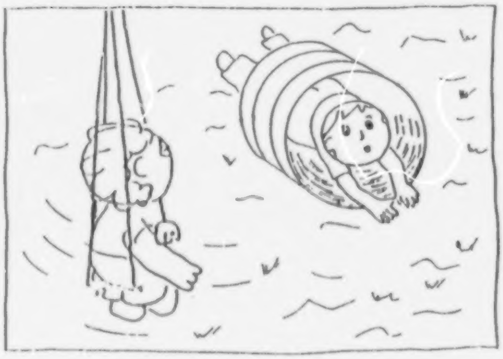


Figure 7.14

Activity Card #32
Control activity: children playing in playground.

| | |
|---|---|
| TRIANGLE | 3.8 |
| PATTERNS | 3.9 |
| OBLIQUE | 3.8 |
| COMBINATION | 3.7 |

| | |
|---|---|
| FORM A | 3.9 |
| FORM B | 3.7 |

| | | | |
|---|---|---|---|
| REPRODUCTION (Body) | 4.3 | REPRODUCTION (Shapes) | 3.6 |
| REPRODUCTION (Group) | 4.1 | REPRODUCTION (Transparancies) | 3.6 |
| REPRODUCTION (Creativity) | 4.1 | REPRODUCTION (Memory) | 3.6 |
| MEMORY (Child) | 4.1 | IDENTIFICATION (Teacher) | 3.6 |
| MEMORY (Teacher) | 4.0 | IDENTIFICATION (Student) | 3.4 |
| | | REPRODUCTION (Graphic) | 3.4 |

Table 7.2

Composite Preference Scores
Children's average preference scores have been calculated for the 4 units, the 2 test forms, and the activity categories (N = 21).

## D. DISCUSSION

Clearly the children were unable to explain what the Agam Program is in other than descriptive and concrete terms. This inability reflects the general difficulty of preschool children to generalize their experience into abstract terms. It is this very disability which posed the problem of designing an instrument to measure children's preferences, as mentioned earlier.

For this reason, it is especially interesting that this exploratory study allows us to conclude a number of abstract generalizations about children's preferences in the Agam Program.

The study supports the observations that children are very positive about the Agam Program and its activities. This finding is especially convincing when one compares the scores of the various Agam activities with the scores for the "control" activities, which were chosen for their high intrinsic interest.

A fine-grained analysis shows that there is a wide variety of likes and dislikes, i.e., what one child loves is not necessarily what his or her friend will love as well, and vice versa. This analysis provides one explanation why it is so common to find children enthusiastically engaged in the Agam Program. Given any activity in the program, the odds are very high that at least some children will be quite enthusiastic about it.

Beyond these individual differences, and the overall high score for the activities, a strong pattern emerges. Those activities which are physically-oriented and gross-motor in nature (reproduction with body and group) and open-ended (reproduction with creativity) are most popular, while those activities which demand fine-motor co-ordination and focus on reproducing a single correct visual answer (reproduction with transparencies, forms, and drawing; reproduction from memory) are generally least popular. Two suprises involve the low popularity of the identification activities (probably because the children are most passive with them) and the high popularity of the memory cards. The popularity of this latter activity may indicate that it is easier than the fine-motor reproduction activities. At the same time, it may indicate that the children love the intellectual challenge associated with remembering the correct combinations of shapes.

An interesting finding is that, in general, the children felt that the Agam Program would make contributions to the school-related areas of reading, writing, math and drawing. However, they were less certain that the program would contribute to "out-of-school" fields, such as decoration, organizing a party and playing games in the party (see above, in point 3 of the findings). The children seem to believe that the program and its concepts are relevant to formal schooling but not to life outside the school. What might explain this discrepancy? One explanation is that the children experience the Agam Program only within the school context and therefore perceive its relevance only within this setting; such "contextual dependency" typlifies children's thinking (A. Venger, personal communication). Explicitly bringing more "out-of-school" activities into the program might remediate this perception.

We were unable to shed light on the hypothesis that specific groups of children (e.g., according to sex or intelligence) have different preferences. There were too few children in the sample to permit such an analysis, though future studies should explore this avenue.

In summary, the visual projective attitude test proved to be a useful tool in illuminating how the children themselves felt about the Agam Program and its activities. This research instrument, and others like it, should be used in future studies of children's attitudes and preferences in the Agam Program.

# VIII. TEACHERS' PERCEPTIONS

How did the participating preschool teachers view the Agam Program, in terms of its effects on their students? In the following section, information relevant to this question is presented from three major sources: (1) written answers to questions presented to the preschool teachers (who had participated in the Agam Program for two years), (2) a questionnaire presented to the participating preschool teachers, and (3) informal discussions and observations in the preschools.

The questions posed to the participating preschool teachers were given as part of their inservice training. In this section, the teacher quotations come from their written answers to two questions:

> (a) "How would you compare the children who participated in the Agam Program during the past two years with the children in your preschool in earlier years?"
>
> (b) "Did the children trained in the Agam Program transfer what they learned to new areas? Did they make new connections or new creations in areas which were not explicitly part of the Agam Project?"

The questionnaire asked the participating teachers to judge how much the Agam Program contributed to their children, in different fields.

Information relevant to teachers' perceptions of the Agam Program was also gained via classroom observations and discussions with the teachers. Throughout the two-year study, members of the Agam Project observed the teachers frequently; these observations often lead to discussions about the program with the teachers.

The teachers' perceptions will be summarized in regard to the following topics:

(A) Transfer of skills and concepts,

(B) Relevance of the Agam Program to different fields,

(C) Development of work skills and habits,

(D) Development of motor skills,

(E) Development of school readiness, and

(F) Development of creative thinking.

## A. TRANSFER OF SKILLS AND CONCEPTS

The Agam Program aims to develop specific skills and concepts. Do children who participate in the program apply these skills and concepts, spontaneously, outside of the program itself?

The evidence -- taken from the preschool teachers' reports and the classroom observations -- indicates an affirmative answer to this question. It seems that the children spontaneously applied the skills and concepts they had learned in the Agam Program to their daily lives. This evidence relates to the following areas: observational ability, visual memory, global and analytic perception, flexibility of perception, and visual concepts.

1. Observational Ability. The teachers presented numerous examples of how their preschool students applied this ability to new situations. One teacher wrote:

> "The children look at certain objects and immediately see how they are composed. For example, one boy sat with his legs at an oblique slant and he immediately said, 'Sarah, see how my leg is oblique!' Or, if we went on a trip, the children would point out that the road was oriented as an oblique line. Or, while discussing the story in a picture, the first thing the children saw were the different geometrical forms and their positions."

Each teacher mentioned similar examples of how children spontaneously observed and pointed out, in various day-to-day situations, concepts they had learned in the Agam Program. For example, during a play period in one preschool, a child discovered there were "patterns" (the concept taught in Unit 3) inscribed on the base of a wine cup. During the rainy season, several children spontaneously commented that the boots near the door were standing in a "vertical position" (the concept taught in Unit 7).

2. Visual Memory. The teachers noticed that many children applied their visual memory, developed in the Agam Program, to new situations. The following is an example of such application:

> "The children's visual memory became quite well-developed. One morning, my assistant routinely placed some objects on a table in a particular way. The next day, the children asked her if they could replicate that particular pattern. A girl, who particpated in the Agam

> Program, reconstructed the pattern exactly and said: 'We do a lot of things like this in the Agam Program. Our teacher sets up something, shows us, takes it apart, and then we're supposed to make it just as she did.'"

3. Analysis and Synthesis. The Agam Program develops analysis and synthesis in regard to visual perception: the former deals with the process of breaking down complex visual stimuli into their component parts, while the latter deals with a global grasp of the visual field. The teachers gave evidence that their young students applied each of these skills to new situations.

Children transfer their analytical visual abilities to new areas. One teacher wrote:

> "The program helped the children develop new skills and directions. Once, for example, the children were supposed to draw the wall of the Old City of Jerusalem. They figured out that the wall is made of rectangles and that the stones are made up of vertical and horizontal lines. So it was very easy for them to make the drawing. The same thing happened with the Star of David. They knew that it's made up of two triangles and immediatley drew it without a problem."

Another teacher wrote that the program helped children apply their visual skills to analyze a picture into its component parts, concentrating on the essential elements:

> " (The program helped the children develop) realistic and exact observation, clear and sharp perception and a sensitivity for fine visual distinctions, for example, in the area of making descriptions. Most of the children would describe a picture without focusing on the essentials. Today they know how to focus on the essential elements and to give a definition or a name to the picture."

Another example of the ability to visually analyze comes from a teacher who showed her preschool class examples of modern art.

> "The children had a clear non-verbal understanding (of modern art) due to their work with geometrical shapes. When I showed them paintings of Modrianne and some cubistic paintings, the children 'felt at home.' Since the program and modern art use combinations of shapes, the children were engrossed in the examples of modern art they saw. As they turned page after page, they were happy to meet motiffs which they recognized, as well as combinations between them."

Teachers also commented about how the program helped children develop their abilities of synthesis, i.e., putting together the "basic building blocks" into new and creative situations.

4. Perceptual Flexibility. As mentioned in Section II above, one of the skills developed in the program is perceptual flexibility, i.e., the ability to perceive correctly changes in shapes. Children who participated in the Agam Program repeatedly demonstrated this ability.

One teacher wrote:

> "In regard to their free-choice artwork, there was a significant difference between children who participated and who did not participate in the Agam Program. For example, the former children pasted squares on construction paper in all different orientations. However, children who did not participate in the Agam Program usually pasted squares in the same way, usually with one of its sides parallel to the bottom of the page."

Another teacher wrote:

> "At the end of the year, I gave the children pages of construction paper, with holes punched in them, along with yarn and a needle. I told the children to sew the yarn through the holes, to make a picture. The children did this, making many different lines in all directions -- horizontal, vertical and oblique. However, in the previous years, the children (who had not been in the Agam Program) would sew in one direction only.

5. Visual concepts. According to the teachers, the children transfered their understanding of visual concepts to new situations. For example, during a visit to the Tel Aviv Museum, the children noticed a painting made up of many different lines, some of which made up a square that rested on one of its corners.

> "One girl -- who hadn't participated in the Agam Program -- said that this wasn't a square. Then another girl -- who had participated in the Agam Program -- answered that this was a square, and that the shape of a square does not change, even if you turn it on one of its corners."

The above example represents transfer of the "conservation of shape" concept. The concept of "pattern" is another visual concept that was transfered to new situations. Here is a sample of relevant comments from different preschool teachers:

> "After they learned and internalized the concept of 'pattern,' one girl told me: 'You know, a song is like a pattern. It has verses, then the chorus, more verses, then the chorus.'"
>
> "After we finished the booklet on patterns, I noticed that many of their drawings had different patterns around the borders."
>
> "A girl told me: 'My mother's necklace is like a pattern. It has two brown beads, one yellow, two brown beads, one yellow.'"
>
> "When we prepared paper-chain decorations for the Sabbath, using many different kinds of materials, the children naturally made some very beautiful patterns."
>
> "The children made up a game in which they had to play different musical instruments, according to a certain order: for example, drum, tramborine, drum, tramborine. Another game: one child closes his eyes and another child, who leads the game, plays different musical instruments, as mentioned above. The child who closes his eyes has to reproduce the specific musical pattern. It is interesting to note that the children transfered what they learned in the unit on patterns to a musical game which they played at our preschool's music corner. I want to emphasize that the children themself made up and initiated these games."

Likewise, preschool teachers related how their students transfered concepts regarding the relationship between two shapes. For example, in many classes, after the children learned the different possible relationships which could exist between two circles (e.g. separate, tangential, overlapping, inclusive), they spontaneously transfered this knowledge in their work with other shapes. These concepts were spontaneously applied by the children to new situations. As one teacher wrote:

> "When I wanted to teach the technique of printing, I gave the children instructions to look for all sorts of objects and to use them to make prints (note: by dipping them into paint and pressing them onto the paper). During the time we were working with the unit on circles, the children spontaneously looked for many objects that included circles and they printed them very nicely, creating pictures with circles that were tangential, inclusive and separate in different shapes and colors."

## B. RELEVANCE OF THE AGAM PROGRAM TO DIFFERENT FIELDS

An analysis of a questionnaire presented to the participating teachers (see Table 8.1) show that most of the teachers felt that the Agam Program "contributes a great deal" to skills specifically developed by the program, e.g., observational ability, imagery ability, graphic skills, visual memory and creativity.

The questionnaire also included skills which are not specifically developed by the Agam Program. Most teachers felt that the program contributed little to some of these skills, such as self-expression, physical fitness, oral expression and musical ability.

However, it is interesting to note that the teachers felt that the Agam Program "contributed very much to several skills and characteristics not explicitly developed by the Agam Program, such as positive self-image, reading readiness, writing readiness, spatial planning and aesthetic sensitivity.

These results, based upon the teachers' perceptions, reinforce similar results reported above in Chapter VI, taken from the children's performance on cognitive transfer tests.

## C. DEVELOPMENT OF WORK SKILLS AND HABITS

Participation in the Agam Program makes special demands on the children in terms of works skills and habits. For example, there is an emphasis on precise work. As noted in Fig. 8.1, the preschool teachers felt that the Agam Project significantly developed "awareness of exactness" in the children.

Success in the program also requires persistence, concentration, and the ability to work both independently and in teams. The preschool teachers often noted how the program develops these important work habits. Considering the program's activities, this common perception should not be surprising. Thus, in the Agam Program, children learn to "pay close attention" during the short time that memory cards are presented to them. Also, reproducing a given diagram with transparencies or plastic figures requires extended attention to the given task. In addition, many of the tasks require independent work by the children, while others require close cooperation with others.

Another skill that was observed frequently by the teachers throughout the implementation of the program was that of peer learning, i.e., the ability of children to teach and

## Table 8.1

### Teacher Perceptions of Agam Program Impact

Preschool teachers, who had participated in the Agam Program for two years, were asked to judge how much the program contributed to different fields. The marks represent average scores (N=24).

16-21 Contributes a great deal
11-15 Contributes
6-10 Contributes a little
1-5 Does not contribute

AREAS

1. Imagery Ability (20.5)
2. Positive Self-Image (19.76)
3. Geometry (19.65)
4. Observational Ability (18.9)
5. Visual Memory (18.71)
6. Reading Readiness (18.16)
7. Awareness of Exactness (18.04)
8. Writing Readiness (17.57)
9. Fine-Motor Coordination (17.04)
10. Spatial Planning (17)
11. Aesthetic Sensitivity (16.8)
12. Arithmetic (16.38)
13. Analysis and Synthesis (16.19)
14. Social Ability (15.31)
15. Creativity (15.31)
16. Independence (14.28)
17. Free Drawing (13.28)
18. Problem-Solving (13)
19. Self-Expression (11)
20. Physical Fitness (9.75)
21. Oral Expression (9.5)
22. Musical Ability (9.25)

learn from each other. Once again, there appears to be a clear connection to the program's activities. The various tasks in the Agam Program are easy to present and to check, making it possible for children to work together and learn from each other.

## D. DEVELOPMENT OF MOTOR SKILLS

All the teachers were enthusiastic about the effect of the Agam Program on the development of children's fine motor skills.

The teachers noted that the program gave children many opportunities and the motivation to engage in fine-motor coordination. These perceptions reinforce the children's achievement on tests measuring fine motor skills, discussed above in Chapter VI.

## E. DEVELOPMENT OF SCHOOL READINESS

Preschool teachers repeatedly mentioned that, based upon their intuition, children participating in the Agam Program would be better prepared for first grade than their other students who had graduated kindergarten in previous years. As one teacher wrote:

> "As I see it, a child who learned in the Agam Program will have an easier time in first grade than a child who didn't learn in the program, given the same background. First, he would have a better background in mathematics, since he would have more knowledge and skills relating to different forms and lines. He would also have more experience with angles, rulers, and the like.
>
> "Also, as I see it, he would have an easier time learning to write, since he learned how to quickly identify and reproduce different shapes and since the program develops a child's fine-motor ability. He would also have developed a better memory ability."

Another teacher wrote:

> "The children who participated in the Agam Program are leaving with a great deal. They are more precise in their work, they remember well what they learned in the preschool, they have mastered clear and structured concepts with which they will be able to work in the future. This is a wonderful preparation for first grade..."

Although developing "school readiness" was not an explicit goal of the Agam Project, many preschool teachers echoed the above remarks.

It is interesting to note detailed quantiative research on the Agam Program bears out these teachers' qualitative comments. Specifically, students who participated in the Agam Program in the 1983-85 research cycle (Razel and Eylon, 1990a, 1990b) scored significantly higher on school readiness, especially in the areas of writing readiness and geometry readiness. The same results are true for children who participated in the 1985-7 research cycle, as presented above in Chapter VI.

## F. DEVELOPMENT OF CREATIVE THINKING

Creative thinking represents a different level than the transfer of concepts. Unlike the former, in creative thinking one demonstrates evidence of making new connections and reaching a higher level of synthesis.

A teacher of 3-year-old preschoolers who participated in the program wrote:

> "In their free drawings and artwork, it seems to me that the children's development was enormous. The 3-year-olds drew magnificently. Usually children of this age don't draw pictures that are so colorful and imaginative. Everyone who entered the class couldn't believe that such young children had drawn these pictures."

Another teacher detailed how her students transfered concepts from the Agam Program in their creative work which revolved around the Jewish holidays:

> "At first I was skeptical about the effect the program could make on the children's creativity. But I was satisfied with the creative experiences the program provoked.
>
> "During Chanukah, while we were studying the horizontal line in the program, the children made horizontal candle-holders for the holiday. During Purim, the oblique line was dominant in the children's creative work and was expressed in all their work: Esther's crown, the clown's hat, skirts, dancers, flags, hamantaschen. During Independence Day, the Stars of David were easier for the children to draw than in previous years; this is usually difficult for children to draw. Drawing patterns with the Stars of David gave them more confidence in their drawing, as well as aesthetic enjoyment.

> "For Independence Day, we constructed the map of the State of Israel, using the plastic geometrical forms from the Agam Program. I suggested that the children include everything that can be found within Israel. The children constructed flowers, trees, houses, railroad tracks, tents, mountains, and all with the plastic forms. On Lag B'Omer we rebuilt the map of Israel, including the traditional holiday bonfires.
>
> "The greatest experience was when the children built the Old City of Jerusalem. I divided the children into different groups: building the Old City with solid blocks, with table blocks and with clay. I didn't consider having a group work with the Agam Program's materials, because I thought the children would have great difficulty constructing the arched roofs of Jerusalem. (Editor's Note: the program's materials include plexiglass circles, squares, triangles, and straight rods, but no arches). But something exciting happened! A group of children entered the room where we keep the Agam program's materials. I didn't enter the room for a while, and the children played quietly. Later, when we were putting away the toys and games, my assistant and I couldn't believe our eyes! In the room, the children had built many small and larger houses on the floor ... with the arched roofs! How had they done this? They placed half of the circle behind a square of the proper size and made houses with the arched roofs!"

Another teacher commented on how the children created during their free time:

> "During their regular arts and crafts sessions in the preschool, the Agam-trained children invested more thought and more imagination than the other children. For example, one child, who always drew and pasted his work on a flat surface, started to paste in 3-dimensions, something I never saw him do before we started to work with the Agam Program."

* * * * * * * * * *

To summarize, the participating preschool teachers perceived that the Agam Program significantly helped their preschool children develop important skills and concepts.

The children spontaneously applied these skills and concepts to their daily lives. The Agam Program, according to the teachers, also contributed to the development of important characteristics and skills not explicitly stated by the program. The teachers reported that the program significantly contributed to the children's development of work skills, motor skills, school readiness and creative thinking.

These findings, based on qualitative data, complement and reinforce similar findings, based on quantitative data, which were reported above in Chapters V and VI.

## IX. EFFECTS ON SPECIAL CHILDREN

In chapters V and VI, quantitative data was presented and analyzed in terms of mean scores and statistical comparisons between experimental vs. comparison groups. In chapters VII and VIII, qualitative data was also presented and analyzed in terms of experimental vs. comparison groups. The present chapter presents qualitative data of a different sort: case histories of particular children who made dramatic progress due to the Agam Program.

### A. CASE HISTORIES

Within the context of the teacher inservice training, the preschool teachers were encouraged to observe and write about students who were especially helped and advanced by the program. The following comments are invaluable, since they are based on the teachers' direct experience. Being with the children daily enabled the teachers to observe the progress of individual students over a two-year span.

#### 1. SARA

"Sara is a thin, blond, sweet little girl who has a twin sister from whom she was separated for the first time, when entering into preschool. She comes from a family of six and her parents suffer from serious health problems. Sara's sister is favored at home. Nonetheless, it was very painful for Sara to be separated from her mother. As a result, Sara had difficulties in integrating into the preschool.

"She would enter the kindergarten, sit down in a corner and would remain silent even when the teacher referred to her directly. Sara had suffered from illnesses from a very early age and thus was physically weak. At the beginning of the year, there were doubts whether she belonged at all in a regular kindergarten framework as she was weak in all areas. Socially she did not cooperate, neither during the recess nor during the actual teaching.

"Each time I called for her group to do the Agam Program, Sara would be the first to come. She began to participate with the very first activities. For example, when we played the memory game from the Circle unit, Sara immediately grasped the right memory card. Naturally, she received a great deal of encouragement. She began to take part in the Agam Program like all the other children and even accepted them. She constantly succeeded and began to pride herself in this, thus strengthening her self-confidence. She really started behaving like the "winner" of the group. Gradually this confidence was transferred to other areas in the preschool; she began to draw, to glue and to work in all the creative corners of the preschool. She acquired friends and started to be a happy child.

"At the end of the first year, it was impossible to recognize Sara. The introverted, quiet child has become mischievous and confident; she is considered to be one of the best-adjusted girls in the preschool. She participates in the formal teaching hour and her answers are always to the point. She is always surrounded by friends and is therefore, ready and mature enough to be promoted to first grade. Her situation has also improved dramatically at home, since the attitude towards her has changed for the better.

"Sara can thank the Agam Program. I see that Sara has opened up to the world through the program which emphasizes the visual domain, rather than verbal language, which is an obstacle for Sara. The moment she saw that she could succeed in 'a game without words,' she developed confidence and transferred it to other areas. As a result, she slowly became a better student."

## 2. ESTHER

"Esther joined our preschool at the beginning of the school year. She was small, thin, very quiet, introverted and reserved. She was cut off from the other children, did not approach any of them and spoke to nobody, including myself. She was lonely and somewhat sad. I wasn't acquainted with her voice because she sat quietly all the time without talking. She didn't distinguish herself in any area of the preschool; neither in the arts and crafts activities, the outdoor play nor any other activity in the preschool. Esther did stand out, however, because of she looked neglected and sloppy. She is a native Israeli but her parents immigrated from Persia and do not speak Hebrew at home. During my work, I was not sure whether Esther failed to understand me because of language difficulties or as a result of more serious problems. Esther simply did not respond. She did everything with great hesitation and after looking in every direction, as she was insecure about her actions. Even moving around from place to place in the preschool made her insecure.

"Esther participated in the Agam Program with the weakest group in the preschool. At the beginning, she behaved as she had untill then - sitting and looking at what I was doing without responding or showing excitement. In contrast, the other children were very excited with the first activity of the program which introduced the large circle.

"Later on, she participated in a circle game of searching for circles which were scattered and hidden in the preschool, but she did so without talking, smiling or running as did her friends when they found a hidden circle. In this activity, Esther had no difficulty understanding my short instuctions because she copied her peers, doing everything they did. This saved her from having to repeatedly face the problem of understanding what was required of her verbally or from failing in her tasks.

"Esther began to feel that she was capable of performing and doing everything that the other children in the preschool did. She started having confidence in herself and carrying out instructions without hesitation and without looking around her too much to ensure that she was doing the right thing. However, she did continue to copy her friends.

"I began to think that Esther was capable of more than I had first expected from her. Therefore, I decided to move her to a better, more advanced group.

"Esther progressively developed more confidence, became aware that she could do what was required of her, and, in return, started to receive much support and encouragement.

"I remember many occasions when Esther would enter group work, skipping and jumping and all smiles. As a result of the program, Esther began to express herself well in the arts and crafts hour. She felt freer and freer in the preschool and spoke to the children and to me. Although her language was not fluent or correct, she now had the courage to speak.

"I actually began to discover another Esther through the Agam Program. This new Esther had the desire to work. I found that her span of concentration was long and that the program had developed her memory and graphic skills. There were mornings when she would arrive to the preschool, asking if her group would work on the Agam Program that day. With this request, I felt that if only for Esther, the whole program was worthwhile. During her second year in the preschool she behaved almost like any other child without any problems.

"Esther continued her progress with the rest of the children - her language improved, although her vocabulary was still poor and her sentence structure was generally incorrect. The Agam Program contributed to Esther's development because the Agam Program did not rely upon verbal expression. Because the program is highly-structured, I also think that the program is good for children who come from an underprivileged environment and with a poor vocabulary."

### 3. DAN

"Dan is a happy, mischievous child but his movements are clumsy. He runs without any purpose; it is hard for him to concentrate and therefore,it is difficult for him to adopt good work habits. He has speech problems (short and unclear sentences) and uses gestures to express himself. These speech problems were reflected in the difficulties he had in making friends. During his first year in the preschool he received speech therapy at the request of the teacher.

"In my opinion the Agam Program helped Dan. Why?

"The first activities are easy. The children do not have to invest too much effort in them; they are short, the shapes are large, colorful and clear, and the program is built systematically and consistently, block after block. In order to participate in the program, Dan did not need words, which were problematic for him and caused him embarassment. The program enabled Dan to feel equal to his friends, both in his ability and in comprehension, thus contributing to his self-image. I greatly stressed his success in these tasks. What was difficult for Dan was the graphic activity, about which he was apprehensive. Neverthless, encouragement motivated him to try and, to my surprise, Dan succeeded quite well in comparison with his friends.

"Dan tried drawing circles at home and every day brought many circles that he had drawn and cut out to the preschool. He was treated for his speech defects, and, in addition, I tried to involve him in other activities, even as a listener. All this help advanced Dan and he showed great progress in other areas, e.g., his drawings became more meaningful. This could be attributed to maturity but there is no doubt that the program increased his self-confidence greatly. His arts and crafts work showed more variety and he approached the creative worktable joyfully. Slowly, Dan revealed himself as having a good memory, easily memorizing 2-3 memory cards and successfully reproducing them graphically from memory. His success definitely contributed to his self-confidence, which in turn helped to rectify his speech defects. His remedial teacher was amazed at his rapid progress and claimed that within a year Dan had closed a gap of at least 2 years.

"It is possible that Dan would have made progress without the Agam Program, but his progress would have taken much longer. Most of the activities in the preschool were verbal and created problems for him.

"The program suited Dan in the best possible way: it capitalized on his ability to identify, remember and reproduce visual concepts, which in enabled him to overcome weaknesses that he had in other areas."

## B. ANALYSIS

The above three case studies are representative of many other examples of "special children" who made dramatic progress in preschool, as a result of their participation in the Agam Program. Based upon teacher questionnaires, we estimate that these children represent about 10% of the children.

What are the common denominators of these "special children"?

Common to these the children is their introversion and deficient communication with the surroundings. They are described as non-social, introverted, closed, as having social problems, i.e., they do not accept assistance from adults or they refrain from cooperating actively with the learning group. Also, they have weak relationships with other children and they often are quiet, reserved and lonely.

Other problems most likely connected with these children are the following:

a. Speech defects. The children were often diagnosed as having speech defects and were treated for this problem. They often had communication problems and suffered from lack of confidence.

b. Lack of environmental stimulation. The children often came from educationally poor environments, one deficient in stimuli and language. Such environments often do not give the child any encouragement, reassurance and support.

c. Concentration problems.

d. Difficulties with fine motor performance.

Given this profile of the "special children," what characteristics of the Agam Program are responsible for making such a marked contribution to the children's progress? The teachers raised several points.

a. Non-Verbal Teaching/Learning. The introverted children described by the preschool teachers, whose behavior manifested itself in defective communication, were given the chance to play and succeed in games without words. They later transferred the confidence gained in this area as well as the reassurance and successes to other areas. The fact that the children were given a tool of visual expression, while the rest of the activities in the preschool were based on verbal communication, was crucial for them.

b. Didactic Qualities of the Program. The program, being structured and enabling systematic work from the easy to the difficult, and in small groups, contributed to the children's self-confidence, reassurance and sense of progress.

c. Diverse Skills. Each child has different abilities. Because different skills are required by the program (identifiation, memorizing, reconstruction with aids, graphic reconstruction). each child has a chance to succeed at a different skill, one which is most suited to his or her own abilities. This aspect of the program contributes to each child's sense of success, making it possible for him or her to do well in the skill he knows best.

The data presented about children's perceptions (Chapter VII) support this point. Although most activities has a wide range of preferences with the children, every child had his or her favorite activities.

d. Flexibility in Adapting Activities. The possibility of adapting the activities enabled the preschool teacher to calibrate the pace of work and the level of difficulty for each child. This could be done with the child feeling the difference, thus giving him a feeling of confidence and success.

Naturally, the points presented in this section are only suggestions and not conclusive research findings. However, these impressions are important and should be a point of departure for more systematic research.

# PART 3: CONCLUSIONS AND RECOMMENDATIONS

## X. DISCUSSION

> "...verbal language and analytic thought have dominated human life for so long a time now that it is hard to imagine that there might be other means of translating experiences, valuable for thinking yet altogether different. We have grown used to the idea of other languages, to be sure: the languages of music, of dance, of mathematics and science, the relatively new computer languages.... But the notion that we might benefit from a visual perceptual language as a parallel to verbal analytic thought processes is, perhaps, an idea of our time."
>
> -- B. Edwards (1986)

The Agam Project was established as a long-term curriculum research and development effort in the area of visual cognition. This report, based on the project's second cycle pf research and development, should be viewed in this context.

The following discussion first summarizes the findings in the major research areas, and then considers how these findings illuminate the links between theory, research and practice. The report concludes with recommendations about future directions for the Agam Project.

### A. SUMMARY OF RESULTS

#### 1. Implementation (Chapter III)

During the present study (1985-7), 10 out of the 36 units in the Agam Program were taught to the participating preschoolers. A study of this implementation shows that the program is appropriate for children aged 3-6; it is also well-adapted for the typical Israeli preschool. Activities are well-adapted for three different preschool frameworks, i.e., the entire class, small-group work, and individualized work. Evaluation of the teacher-training program shows that it is crucial for the success of the Agam Program.

#### 2. Basic Visual Skills and Concepts (Capter V)

Children in the Agam Program demonstrated a significantly higher ability in their ability to identify visual concepts in complex contexts. They demonstrated a more robust understanding of visual concepts, more sophisticated understanding of these concepts and better application of these concepts in complex visual settings. They also performed better on most visual memory tasks.

3. Cognitive Transfer Effects (Chapter VI)

Effects of the Agam Program generalized beyond the specific tasks presented in the program. Children in the Agam Program demonstrated significantly better transfer skills in the area of observation. They were much better able to reproduce a visual stimulus when it conflicted with their "internal image," scored significantly higher in fine-motor skills and in tasks related to mathematics readiness.

4. Children's Perceptions (Chapter VII)

Naturalistic observations provided much evidence that the children received the Agam Program with great enthusiasm. A follow-up study using a visual projection test provided two explanations. First, the program's activities were intrisically motivating to the children; the students' response to the activities compared favorably to their response to "control" activities, chosen for their high intrisic interest. Second, the diversity of activity types enahnced student interest; while children's reactions to each activity type varied, each child found certain activity types particularly enjoyable. In general, the most popular activities were tasks which involved physical activity or open-ended creativity.

5. Teachers' Perceptions (Chapter VIII)

Teachers noted that the Agam Program contributed beyond the acquisition of specific concepts and skills. They gave extensive examples of how the program was relevant to new situations, new fields, the development of work skills and habits, as well as the development of school readiness, and creative thinking.

6. Effects on Special Children (Chapter IX)

Although the data indicate that the Agam Program helped all the participating children, there appeared to be special children who were dramatically helped by the program. Case histories of such children indicate that they tended to be non-social, introverted, and non-verbal. The Agam Program apparently offered these children a means of succeeding, which was otherwise unavailable to them, resulting in marked improvements in their self-image, social adaptation and cognitive development.

## B. INTEGRATING THEORY, RESEARCH, AND PRACTICE

The above findings suggest several challenging issues for discussion: (1) transfer, (2) creativity, and (3) educational practice.

### 1. Transfer

What can explain the program's transfer effects? How can a program which trains visual concepts and skills have such pronounced general effects on children's thinking?

The main explanation we offer of the Agam Program's transfer effects is based on the notion that the program develops the child's visual language. Thus, the child learns a set of rules, techniques and abilities that are generative in the Chomskian (1957) sense, i.e., they permit the independent production of visual language by the child. Just as better verbal language produces better verbal thinking (Gagne and Smith, 1964), so it can be reasoned that a more developed visual language can produce better visual cognition, which itself is tied to general cognition.

This explanation is supported by diverse lines of evidence. For example, there is ample evidence that visual concepts and skills are related to cognitive development. This connection, presented earlier in Chapter I, is the basis for the educational significance of visual cognition, and it is understood by researchers of early childhood development.

For example, Shapiro (1979) points out that copying ("reproduction," in terms of the Agam Program) offers "a paradigm of the transformation of perceptual information into overt action," and that this transformation is related to the child's cognitive development. She writes:

> "Perception is not merely passive registration but a sequence of actions. And (reproducing) 'a form like that one' is a shorthand expression for a set of performatory acts requiring, at the least, coordination of eye and hand, monitoring of hand movements, as well as cognitive strategies that determine the content, sequence, and style of the performatory acts."

It is interesting to note that the Agam Program places a great deal of emphasis on the skill of reproduction, thus giving children many opportunities to develop the relevant cognitive strategies.

But the connection between the learning of visual concepts and skills and the development of general thinking skills is probably even more profound than suggested by Shapiro. Through engaging in this learning, the child develops symbolic functioning and symbol formation, which is an important basis for human thought.

There are a number of ways to conceptualize the developmental process of symbol formation. One conceptual scheme is based on the notion of "symbol systems." Humans are characterized by their ability to invent and use different symbol systems, not only in the area of verbal language, but also in the realms such as mathematics (number systems), kinesthetics (movement systems), music (musical notation), and the visual-spatial realm. This line of thought posits that people use each of these symbol systems, each according to its own "rules," to selectively absorb, store, manipulate, transform and create knowledge (Gardner, 1983).

Another way to conceptualize how symbolization develops is to focus on children's ability to develop "representational competence" (Copple, Sigel and Saunders, 1984). The assumptions of this line of thought are the following:

a) Human beings understand their world through representations of it.

b) The ability to make representations of reality develops in an orderly sequence.

c) This ability ("representational competence") develops fully only in response to interactions with the appropriate physical and social environments.

According to this line of thought, development of symbolic functioning takes place on two parallel tracks: (1) in the use of an internal and coherent representational system to represent real objects and experience, and (2) in the use of external and physical objects to stand for other real objects (Sigel et al., 1977). The first track can be understood as "thought power," based upon explicit symbol systems, while the second track can be understood as "conservation of meaning," as illustrated by the following example:

> "A child who conserves meaning can...treat a photograph of a dog, a toy dog, the word "dog," and a schematic drawing of a dog all as representations of the actual three-dimensional dog. Though their visual qualities differ, the representational function of each of these objects is the same."

One of the salient characteristics of the Agam Program is that it engages in "multiple modes of representation." Thus, it may not be surprising to expect that children who participate in the Agam Program develop "representational competence," as defined above.

In short, the Agam Program's success in training children in general cognitive skills, which go beyond the program's specific concepts and skills, may derive from the program's success in systematically cultivating the visual language. In turn, this visual language may help the child to develop cognitive strategies, skills in symbolization and representational competence, all of which could contribute to the program's transfer effects.

## 2. Creativity

In the teaching of creativity, the Agam Program takes the position that children first need to be taught basic concepts and skills; later they should be given open-ended opportunities to utilize and creatively apply these same concepts and skills (see Chapter II).

This approach may seem to "run against the grain" of educational practice. One might think that the best way to develop the visual language in children is simply to expose them to an open-ended environment rich in visual stimuli. However, upon closer examination, it appears that such exposure by itself is inadequate. In her review of visual arts education, for example, Smith (1983) discusses the educational preference for "the principle of noninterference," which has dominated the field, and concludes that this principle is not supported by modern psychology and child development.

To highlight this point, it is useful to consider the example of computer "microworlds," such as those offered by the computer language LOGO, which is designed to teach children powerful mathematical concepts. Research has shown that simple exposure of children to these microworlds is not effective. A more explicit curriculum and well-trained teachers seem to be essential ingredients for success (Pea and Sheingold, 1987). The analogy to the teaching of creativity is obvious.

What, then, was the program's effect on the children's creativity? It is difficult to answer this question because of the difficulty in defining and measuring creativity. On one hand, the task from the Torrance test for measuring creativity did not show a clearcut statistical difference favoring either the experimental or comparison group. On the other hand, other creativity tasks (e.g., tasks A5, B1 and F8, discussed in Chapter VI) did show significant differences, in support of the experimental group. Furthermore, teachers provided many reports of children's creative behavior, indicating a very positive influence of the Agam Program on children's creativity.

Thus, the Agam Program seems to develop children's creativity. But given the difficulties mentioned in defining and measuring creativity, a more definitive answer to this question must await future development, implementation and research of the Agam Program.

## 3. Educational Practice

The present research clearly supports the educational significance of teaching visual cognition explicitly and systematically. Yet, judging from conventional practice, one would assume that there is little value to the development of visual cognition. Why, then, is this area neglected in educational practice?

Perhaps one reason is the commonly-held bias that visual perception itself does not involve thought and, therefore, is unworthy of serious attention. Arnheim (1969) traces this assumption to ancient sources. He points out that the Greeks and Romans differentiated between abstract and rational thought, which they idealized, while regarding the senses with distrust. The perpetuation of this bias could explain the lack of attention given by schools to visual training. This bias is articulated by the historian, A.F.C. Wallace:

> "Indeed, it has become conventional to assume that thought itself is merely a kind of internal speech and to disregard almost completely those kinds of cognitive processes which are conducted without (verbal) language, as though they were somehow more primitive, and less worthy of intellectual attention." (quoted in Ferguson, 1977, p. 836).

The cognitive development theory of Piaget may also have contributed to this assumption that non-verbal cognitive processes are "more primitive." Piaget's notion -- which has been extremely influential within educational circles during the last 50 years -- is that a child progresses from a "sensory-motor" stage to a "concrete operations" stage of thinking, and only later to a "formal operations" stage, in which the pinnacle of abstract thought is reached. Even Piaget's treatment of the child's conception of space and geometry is placed within this hierarchical framework in which the figurative aspect is subordinate to cognitive operations. (Piaget and Inhelder, 1967; Piaget, Inhelder and Szeminska, 1960).

It is interesting to note that not all psychologists agree with Piaget. For example, modern Soviet psychology has a long tradition of research on visual thinking. According to this school of thought, visual thinking and abstract thinking develop in tandem and are mutually complementary, even at the highest cognitive levels (Venger, 1990). However, Soviet psychology has not been influential in effecting current educational practice.

Another reason for the neglect of visual training in education may be that the culture of schools is largely word-oriented (in the Hebrew language, "school" is translated as "house of the book"). Thus, the school would select for teachers and educators who are highly verbal, and it would follow that such individuals would have little interest in teaching -- much less in designing -- visual educational programs.

Regardless of the reasons for the neglect of visual training in schools, it would be wise for educators to take another look at visual cognition. There is a need to break down the simple dichotomy that "sense-oriented (non-verbal) is primitive," and that "abstract-oriented (verbal) is advanced."

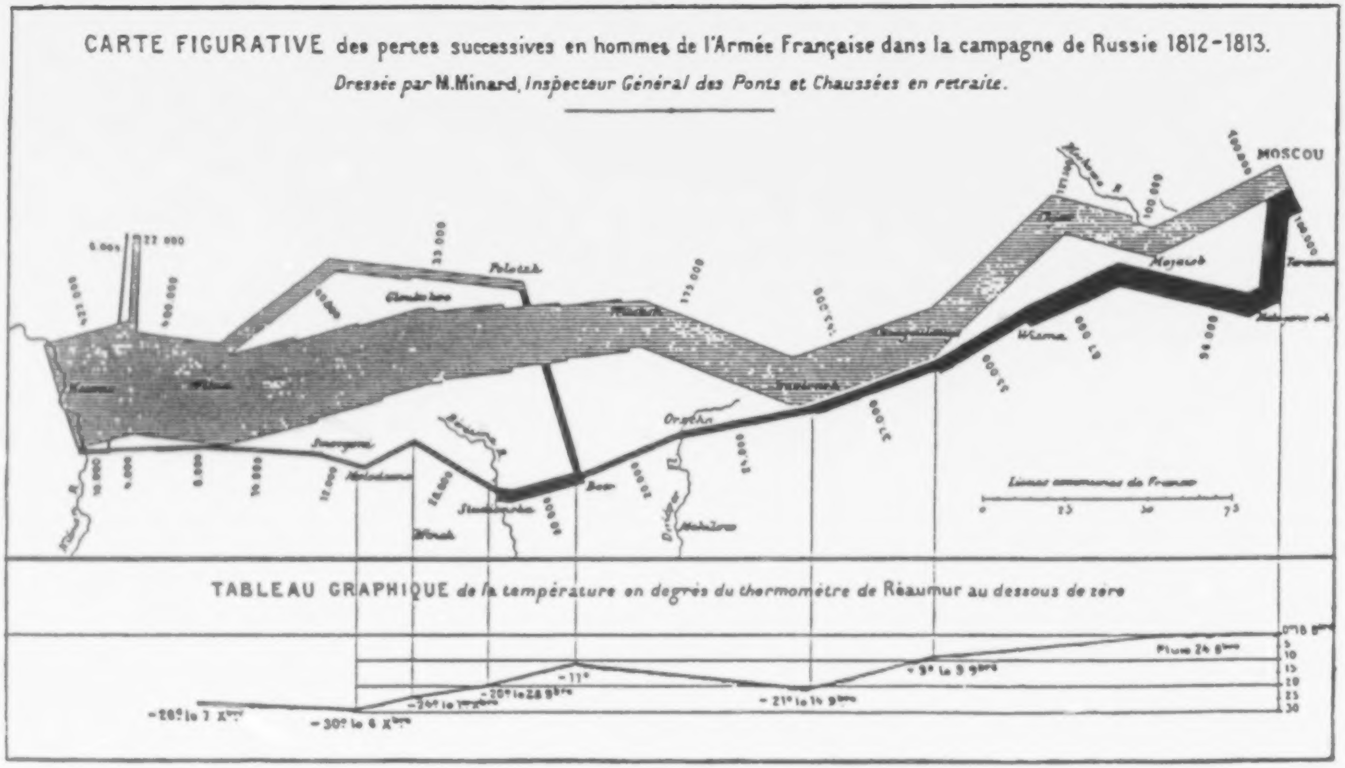
The visual world is rich and varied, with many different levels of meaning, ranging from the concrete to the abstract. Different visual representations deal with "real objects" (e.g., models, diagrams, architecture drawings, paintings, etc.) as well as with "abstract ideas" (e.g., tables, graphs, charts, etc.). Appropriate use of each different representation can be helpful. And each is a part of "the visual language." "the visual language."

Explicit and systematic training in concepts and skills of the visual language can have a great impact in many diverse fields. Visual cognition in mathematics and the sciences has been mentioned often in this report. The Agam Program trains many of the skills which are relevant to success in these areas, e.g., visual analysis and synthesis, the ability to view visual stimuli at different levels of detail, the ability to mentally manipulate visual stimuli and visual memory.

Perhaps visualization is important in math and the sciences because it enhances "a global and intuitive view" in understanding these areas (e.g., Hershkowitz, 1990). Fishbein (1987) claims that intuitive cognitions, by nature, are often associated with visualization and that "visual representations are an essential anticipatory device."

But nearly every field involving human cognition can benefit by the use of visual representations, and for the identical reasons. Figure 10.1 shows how the visual language can contribute to a completely different field: history. It is a document of immense impact and power, described as "perhaps...the best statistical graphic ever drawn" (Tufte, 1983). Undoubtedly, this multivariate gem can significantly deepen one's understanding, perhaps in ways that go beyond the written word.

Clearly, the point is not to train the visual language at the expense of the verbal, or vice versa. Rather, the educational aim should be to strike a complementary balance between these two different languages and ways of thinking.



Xbre = December

Figure 10.1

9bre = November

8bre = October

Napoleon's Russian Campaign of 1812.

This graphic, by C. Minard (1781-1870) "shows the terrible fate of Napoleon's army in Russia. Beginning at the left on the Polish-Russian border ... the thick band shows the size of the army (422,000 men) as it invaded Russia in June 1812. The width of the band indicates the size of the army at each place on the map ... The path of Napoleon's retreat from Moscow is depicted by the darker, lower band, which is linked to a temperature scale and dates at the bottom of the chart. It was a bitterly cold winter, and many froze ... the crossing of the Berezina River was a disaster, and the army finally struggled back into Poland with only 10,000 men remaining." (Tufte, 1983)

## RECOMMENDATIONS

The central goal of the Agam Project is to foster children's visual cognition. Given what we have learned about the Agam Program and about children's abilities in this area, we make the following recommendations, which relate to (a) the implementation of the program, (b) the continued development of the program, and (c) research directions.

### A. Implementation

Our research firmly demonstrates that the Agam Program makes significant educational contributions to preschool children.

We are convinced that proper preservice and inservice training is an indispensible ingredient of the program's success in the preschools.

Currently, costs for participating preschools are relatively high. Thus, in order to implement the Agam Program in a large number of preschools, special efforts must be taken to prepare the proper organizational and economic foundation.

Recommendations:

1) The Agam Program should be made available for wider implementation in Israeli preschools.

2) An implementation center should be established. This center, which would maintain close links with the Agam Project at the Weizmann Institute, would be responsible for all the details involved in initiating the Agam Program in preschools and continuing with proper inservice training.

3) A special fund is needed for the establishment of this implementation center.

4) A cooperative effort should be made to provide preservice training for Israeli preschool teachers. Specifically, a course for preschool teachers on "The Development of Visual Cognition in Preschool Children" (with implications for the teaching of math, art, science and thinking) should be developed cooperatively by a team from the Agam Project and one or more teacher's colleges.

## B. Continued Development of the Agam Program.

As noted above, the present research was based on only 10 of the 36 units in the program. It may be assumed that a full Agam Program will make even greater contributions to preschool children. In order to assess these contributions, it will be necessary to first complete the Hebrew adaptation of the Agam Program; this work involves refining and pilot-testing about 18 additional units.

Recommendations:

1) All the remaining units of the Agam Program should be adapted and tested in a Hebrew version.

2) An English-language version, based upon the Hebrew version, should also be developed.

3) Computer software should be developed to augment the Agam Program, not to replace it. As a beginning, such software could deal with the memorization aspects of the program (e.g., the flash cards found in each unit).

4) Further development of the Agam Program should be more closely linked with the math curriculum group in the Department of Science Teaching. Such a linkage makes sense due to the close connection between visual cognition and the development of early mathematical concepts, especially in the area of geometry; also, this linkage could help insure a continuation of the Agam Program in the early elementary grades.

## C. Research Directions

The orientation of the Agam Project is to conduct "research in context," i.e., research undertaken in relation to a specific curriculum (the Agam Program), a specific audience (preschool teachers and students) and specific concepts (e.g., concepts presented in the program's units). Up to now, most of this research has concentrated on investigating the program's immediate effect.

Recommendations:

1) More emphasis should now be placed upon longitudinal research, i.e., the investigation of possible program effects in the elementary school grades.

2) More emphasis should now be placed on cognitive research within the framework of the Agam Program, i.e., problem-solving and concept development as they relate to visual cognition.

# REFERENCES

> "(My father) had a character more like that of an artist than a scientist as we usually think of them. For instance, the highest praise for a good theory or a good piece of work was not that it was correct nor that it was exact but that it was beautiful."
>
> -- Hans Albert Einstein
> quoted in Einstein:
> A Centenary Volume, 1979.

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# Appendix 1

## THEORIES OF VISUAL COGNITION

According to Pinker (1984), visual cognition is composed of two aspects: visual recognition and visual imagery. The following is a brief survey of recent cognitive theories which relate to each of these aspects.

### 1. Visual Recognition

Different approaches and theories exist which explain the processes of visual recognition. Visual information is received from objects when the eye forms an image on the retina. The representations of the various objects are stored in a long-term memory. The differences in theories relating to the recognition of shape can be found (according to Pinker, 1984) in relation to:

(a) in the various assumptions associated with the representation of objects in long-term memory and related questions, e.g., What is the number of representative shapes for an object? Which group of objects will receive one representation? What is the format of the representation?

(b) in explaining the stages preceding the preprocessing of an image on the retina before matching the representation and the object; in explaining how the retina input or the representations in the memory undergo transformation so that there be maximum correlation between them, and

(c) in terms of the quality of matching which determines which representation in the memory will correspond best with the input.

Initially, theories were suggested which were based on such models as Template Matching, Feature Models and Structural Descriptions (described in detail in Lindsay Norman, 1977). According to the Structural Descriptions Model, shapes are presented symbolically as a structural theory in the form of statements about the shape features and about the spacial relationships between them. The disadvantages of these theories are as follows:

(a) there is no assumption that a perceptual process takes place before matching the shape with the representation in the memory, thus there is no distinction between perception and cognition, and

(b) no attention is paid to the process of recognizing

> the shape as a means of solving problems, i.e. there is no answer to the question of what the recognition process supplies to other cognitive mechanisms connected to problem solving.

A theory which attempts to shed light on the problem of the interface between perception and cognition is the theory of Marr and Nishihara (Marr,1982). The question which the theory tries to answer is this: What are the preliminary visual processes provided for the recognition process and for the visual cognition process as a whole? When separating preliminary visual processes it has been established that these processes are not part of visual cognition. The early processes include a set of information concerning the retina and subsequently 3 methods of encoding the visual information up to the recognition stage. The three methods are:

1. encoding the location of the objects in the visual field,
2. encoding the geometry of surface areas which appear to the viewer (this is called 2 1/2D), and
3. encoding the spacial configuration of the objects (this is called the 3D Model).

According to Marr and Nishihara, information about a shape is not stored in a single model of a global coordinative system, but in a hierarchy of models. Each model represents parts of various sizes and each part possesses its own coordinative system. The visual information is stored in an array of cells, each cell holding a small part of the general information concerning the specific object. Pinker claims that the general problem in creating representations for shapes from input is the choice of a particular field of reference and of shape primitives. However, the shape primitives depend on the type of shape defined as the structural description of the shape primitives. Therefore, Pinker mentions different theories associated with the various methods of preprocessing information.

One of the models for processing information is called Top-Down Processing. The approach of this model is that part of the visual information is based on the assumption that a person has knowledge of the regularities in the world and therefore, the most similar and most suitable description is chosen for a specific object (based on Gregory, 1970; Lindsay and Norman, 1977; Minsky 1975; Neisser, 1967).

Another model for preprocessing information is that of Ullman (1984), called Two-Stage Analysis and it stipulates that the visual systems function according to a particular routine. These routines comprise such simple processes corresponding to the input as: tracing along a boundary, filling in a region etc. When routines function, the output can characterize features of shape and spacial relationships. Where a group of routines is operated it triggers off specific routines employed in recognizing particular objects or a group of objects. According to Ullman's theory the visual routine can be used not only for purposes of recognizing objects but also for geometric reasoning of the visual environment.

An additional approach for preprocessing information is called Massively Parallel Models. According to this theory, the mechanisms used in recognizing a shape are connected to the fact that the information received by the retina is parallel to the shape itself. The theory further states that the unit of information such as size, location and direction is found on the retina and has a mapping unit which matches-up with what exists in the shape. Attneave 1982), Hinton (1981), Hrechanyk and Ballard (1982) suggest models according to this approach. This theory gave rise to a new notion about the term cognition called connectionism, Fodor and Phylyshyn(1985).

## 2. Visual Imagery

In a sense, the subject of visual imagery is less conducive to research than visual recognition, since the direct input and the direct output are unknown. There is no doubt that the phenomenon of imagery actually exists. Different studies have discovered that the use of images can be found in many fields of human endeavor; they are particularly useful in the solving of scientific and mathematical problems. The difficulty in studying the image derives from how it is represented in the brain. For example, does the structure and set-up of the brain contain structures and processes specific to imagery? Does imagery include the application of cognitive processes for information structures whose content is about the visual world? (Pinker 1984)

There are varied approaches and theories dealing with the processes associated with visual imagery. Johnson-Laird (1983) offers two approaches to explain the representation of the image. The first is the imagistic approach according to which images are a separate kind of mental representation. Supporters of this theory are Kosslyn, Paivio and Shepard. There is consensus among the imagistic researchers about the features characterizing Johnson-Laird's imagistic approach (1983) and they are:

(a) the mental processes at the base of the image resemble those at the base of the perception of a picture or an object,

(b) the image is a coherent, integrative representation of an event or object from a particular point of view and the grasping process resembles that of scanning,

(c) the image is influenced by sequential mental transformations in which there are in-between situations matching the condition of the object on which the transformations are made, and

(d) images represent objects.

The second approach, according to Johnson-Laird is a postulative one, claiming that images are epiphenomenal, thus allowing for a single shape representation i.e. strings of symbols which match the images (Baylor, 1971, Palmer, 1975, Phylyshyn, 1973). There is consensus amongst the postulative researchers on the features characterizing the Johnson-Laird postulative approach and they are:

(a) the mental processes leading to strings of symbols matching the image resemble those at the base of the perception of a picture or an object,

(b) the same element or part of an object can be associated with many of the statements comprising the object's description; such a description can be made logically or in a semantic field,

(c) a postulative representation is discrete and digital; sequential processes can be described by small successive increments of variables; a small change in representation will match a small change in the appearance of the object, and

(d) statements are true or false of objects and are abstract in that they do not directly match the words or pictures and their structure is not analogous to that of the objects they represent.

According to Johnson-Laird, the obvious difference between the imagistic and postulative approaches is that the former approach sees the image as representing the object whereas the latter approach views the statement as true or false of objects.

Johnson-Laird (1983) suggests yet another approach which states that the representations are in fact mental models. This approach is directed at clarifying the representations of cognitive images. Mental models are specific representation shapes which are present in different options for encoding information. Unlike the structure of statements, the syntactic structure of mental models is not random. Their structure can change and in the case of models, the mental models can possess two, three or even more dimensions and can be dynamic, representing a sequence of events. One of their advantages is that their dimensional structure can be constructed and can undergo manipulations by the dimensional variables in a controlled manner.

According to this view, there is a connection between mental models and images. Johnson-Laird puts it this way:

> "Images correspond to views of models: as a result either of perception or imagination, they represent the perceptible features of the corresponding real-world objects."

Thus, according to Johnson-Laird, at the base of the image is the model. Despite the specificity characterizing the model, it can still represent a general group of entities.

Pinker (1984) bases the mechanisms operating within imagery according to three groups of models:

1. The models of structural descriptions, serving as a group of theories explaining the representation of shapes for visual recognition, have been found suitable for explaining the mechanisms operating to represent the image according to the postulative approach. Pylyshyn (1981) claims that the representation of space or movement in images indicates nothing about the format of the representation of imagery. Demonstrations thus indicate the content of information which can be represented in an image.

2. The model of an array of cells absorbing information about a certain object, suggested by Marr and Nishihira to explain visual recognition, is suitable for explaining mechanisms working in the imagistic models. Kosslyn (1980, 1981), Paivio (1971) and Farah (1984) claim that in imagery, representations and processes are used which concentrate on the visual approach of Pinker (1984). Images are the models of activation in the structure in which a part or an area of the surface of an object in space is either absent or exists (orientation or location). The medium is structured so that each cell is close to the other. The processes taking place in this medium are sensitive to the location of the cell in the medium i.e. there are primitive operations which are brought to a cell by relative or absolute positioning which moves the contents of one cell to its neighbour and so on. The location in such a medium is systematically connected to the disposition in space of the represented object.

Kosslyn suggests a different theory. For him the medium is a "visual buffer". It is two-dimensional and euclidean and the position of the cells in the array corresponds with that of the visual field. When the cells undergo activation they represent protrusions on the surface. A shape is represented so that the activation model in the buffer is isomorphic to the shape of the visible external areas of the object. Koslyn's theory stipulates that representations in the long-term memorizing of objects, shapes and surface features used in imagery, are shared by those used in recognizing the shape.

3. Hinton's model (1979a, 1979b) is based on assumptions similar to those in Kosslyn's model. One such assumption is that when the image represents information in a special format from a global point-of-view there is also an array in which the spacial position of the represented shape is characterized. However, the shape is characterized according to the model of structural descriptions and not according to an array of cells which absorb parts of the visual field and represent local patches of the shape.

## APPENDIX 2: EXAMPLES OF COGNITIVE TESTS

## TEST A: CIRCLE-SQUARE

(Booklets 1, 2)

Name: ______________ Date: ___________

Teacher: ____________

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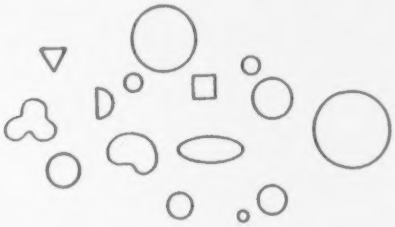
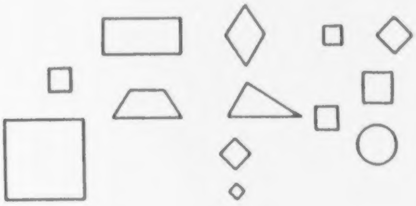
### A-1. Identification of Circles -- Simple Context

(Student marks circles with x)



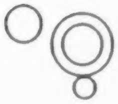
### A-2. Identification of Squares -- Simple Context

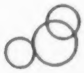
(Student marks squares with x)



### A-3. Reproduction of Circles

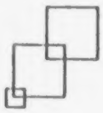
(Student copies the drawings.)





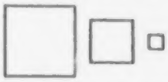
### A-4. Reproduction of Squares

(Student copies the drawings.)



A-5. Creativity: Combinations of Squares

(Student draws as many different combinations as possible, each using the 3 squares. Each combination is drawn in a different cell.)



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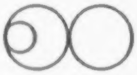
A-6. Memory of Circles: Geometrical Context

(Flash card is presented. Student marks the correct cell with an x.)

1


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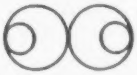

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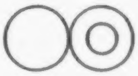

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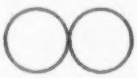

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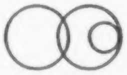

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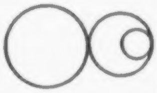

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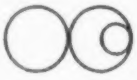

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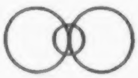
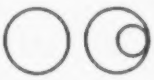
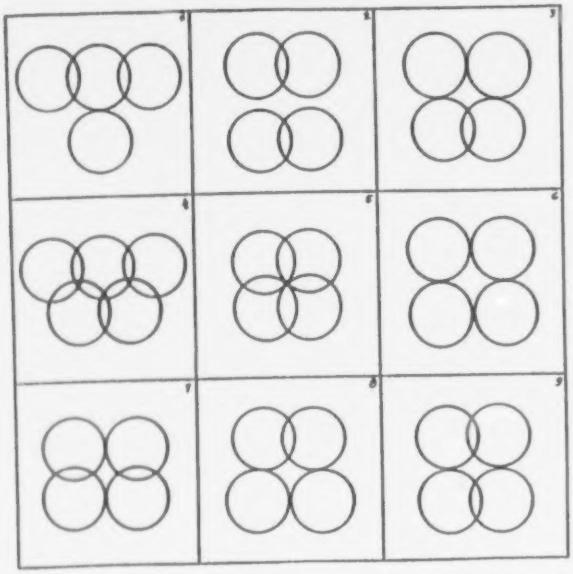
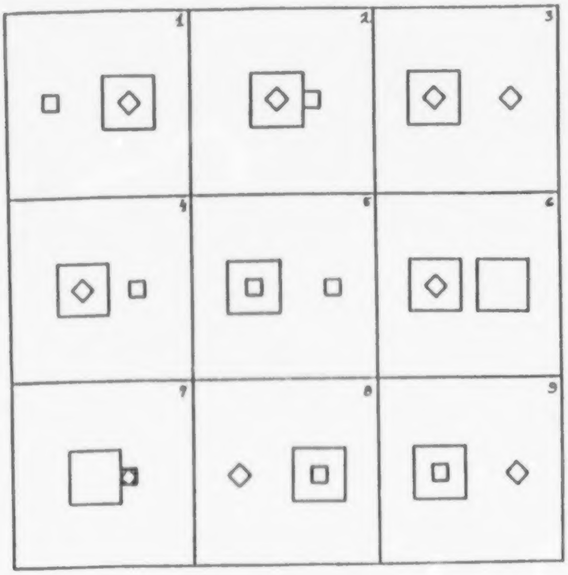


9


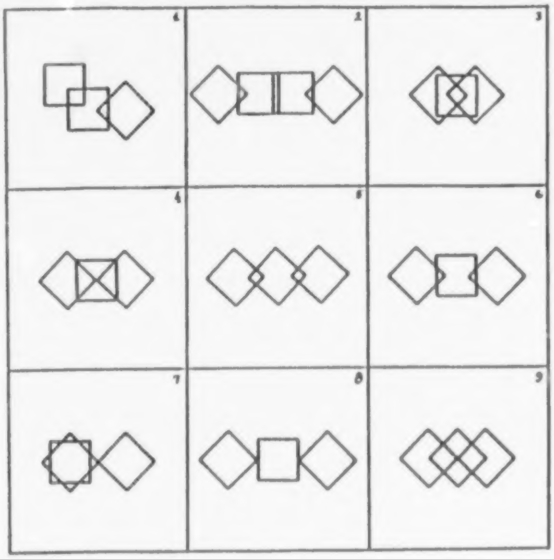
## A-7. Memory of Circles: Geometrical Context



## A-8. Memory of Squares: Geometrical Context



### A-9. Memory of Squares: Geometrical Context



### A-10. Reproduction from Memory

(After seeing flash card, student reproduces it from memory.)

### A-11. Finding Circles in the Environment

(Student is asked to find as many examples of circles in the environment, as possible)

__________ __________ __________
__________ __________ __________
__________ __________ __________

### A-12. Finding Squares in the Environment

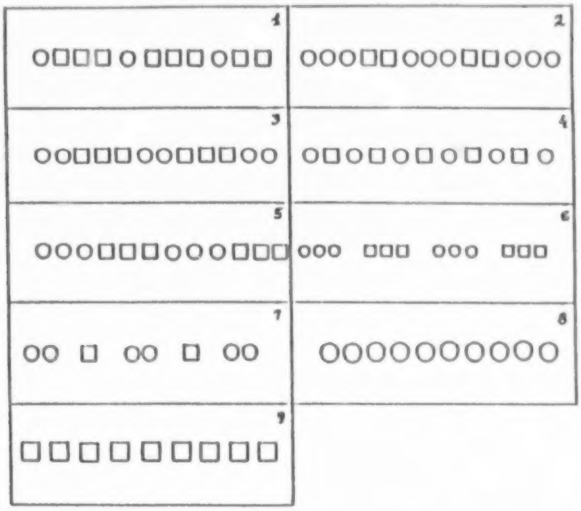
(Student is asked to find as many examples of squares in the environment as possible.)

__________ __________ __________
__________ __________ __________
__________ __________ __________

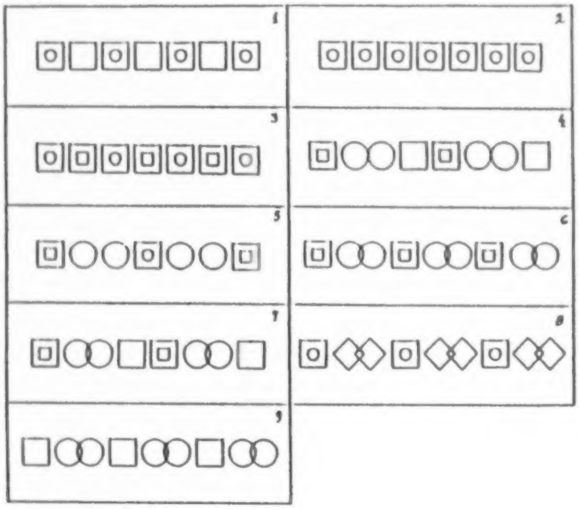
# TEST B: PATTERNS
## (Booklet 3)

B-1. Drawing a Pattern
(Student is shown two examples of the concept, "patterns," with bead necklaces using different shapes or colors. Student then is asked to draw a pattern.)

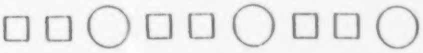
B-2. Memory of Patterns
(Student is shown a flash card with a particular pattern and marks the cell which contains the same pattern.)



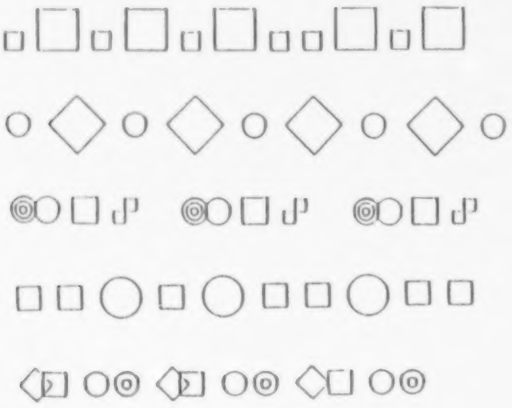
B-3. Memory of Patterns



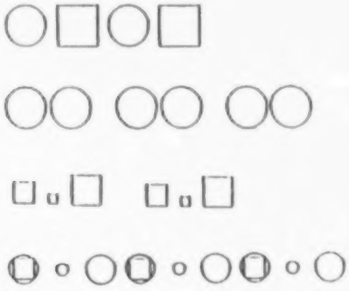
B-4. Reproduction From Memory: Patterns
(Student is told to draw from memory a pattern which is presented on a flash card.)



B-5. Correction of Faulty Patterns
(Student is shown how to identify an error in the first pattern -- by marking the error with an x -- and is asked to likewise note mistakes in the following patterns.)



B-6. Completing Patterns
(Experimenter: "Someone started to draw these patterns and didn't finish." Student is asked to finish drawing the following patterns.)



B-7. Finding Patterns in the Environment
(Student is asked to find as many examples of the concept, "patterns," in the environment as possible.)

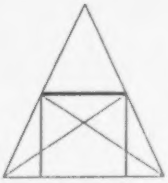
__________ __________ __________

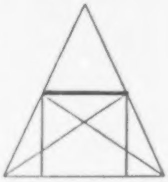
__________ __________ __________

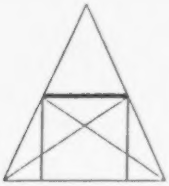
# Appendix 3
## Coding scheme for F8

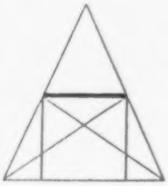
### The task:

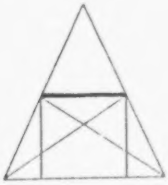
Using the following drawings draw as many different shapes as you can that include the thick line. (the drawings were larger than those shown filling an 8'x11' page)

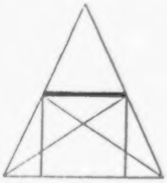










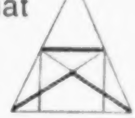


### The coding scheme:

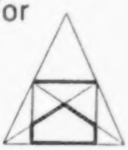
(a) Total number of forms (including repetitions and incorrect forms, e.g. a form which does not include the thick line)

(b) Number of different forms (not necessarily including the thick line)

(c) Number of different forms (not neccesarily closed) that include the thick line. For example:

→ 

(d) Number of different closed forms plus the thick line. For example:

→ 

(e) Number of closed forms in which the thick line is part of the closed form.